



(51) International Patent Classification:

<i>C08G 18/08</i> (2006.01)	<i>C08G 18/66</i> (2006.01)
<i>C08G 18/10</i> (2006.01)	<i>C08G 18/73</i> (2006.01)
<i>C08G 18/12</i> (2006.01)	<i>C08G 18/75</i> (2006.01)
<i>C08G 18/28</i> (2006.01)	<i>C08G 18/79</i> (2006.01)
<i>C08G 18/30</i> (2006.01)	<i>C09D 175/08</i> (2006.01)
<i>C08G 18/32</i> (2006.01)	<i>C08G 18/02</i> (2006.01)
<i>C08G 18/34</i> (2006.01)	<i>C09D 175/04</i> (2006.01)
<i>C08G 18/48</i> (2006.01)	

Josette; P.O. Box 4, 6100 AA ECHT (NL). **LOOIJMANS, Rob**; P.O. Box 4, 6100 AA ECHT (NL).

(74) Agent: **LEVPAT**; c/o Covestro AG, Building K12, 51365 Leverkusen (DE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(21) International Application Number:

PCT/EP2021/051379

(22) International Filing Date:

21 January 2021 (21.01.2021)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

20153239.7	22 January 2020 (22.01.2020)	EP
20153154.8	22 January 2020 (22.01.2020)	EP
20153159.7	22 January 2020 (22.01.2020)	EP
20153240.5	22 January 2020 (22.01.2020)	EP
20153242.1	22 January 2020 (22.01.2020)	EP
20153245.4	22 January 2020 (22.01.2020)	EP
20153246.2	22 January 2020 (22.01.2020)	EP
20153249.6	22 January 2020 (22.01.2020)	EP
20153250.4	22 January 2020 (22.01.2020)	EP
20153251.2	22 January 2020 (22.01.2020)	EP
20153253.8	22 January 2020 (22.01.2020)	EP
20153628.1	24 January 2020 (24.01.2020)	EP
20153630.7	24 January 2020 (24.01.2020)	EP
20187717.2	24 July 2020 (24.07.2020)	EP

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

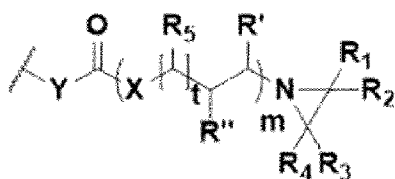
Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(71) Applicant: **COVESTRO (NETHERLANDS) B.V.** [NL/NL]; Ratelaar 39F, 3434 EW Nieuwegein (NL).

(72) Inventors: **OVERBEEK, Gerardus, Cornelis**; P.O. Box 4, 6100 AA ECHT (NL). **STALS, Patrick, Johannes, Maria**; P.O. Box 4, 6100 AA ECHT (NL). **VAN DER ZWAAG, Daan**; P.O. Box 4, 6100 AA ECHT (NL). **BÜCKMANN, Alfred, Jean, Paul**; P.O. Box 4, 6100 AA ECHT (NL). **LANGERMANS, Hermanus, Adrianus**; P.O. Box 4, 6100 AA ECHT (NL). **VAN DIJK, Stella**,

(54) Title: COATING COMPOSITION



(A)

(57) Abstract: The present invention relates to an aqueous coating composition comprising a multi-aziridine compound and a carboxylic acid functional polymer, characterized in that (i) the composition is an aqueous dispersion having a pH ranging from 8 to 14, (ii) the aqueous dispersion comprises particles X which particles X comprise multi aziridine compound and particles Y which particles Y comprise carboxylic acid functional polymer, and (iii) said multi-aziridine compound has: a) from 2 to 6 of the following structural units A; b) one or more linking chains wherein each one of these linking chains links two of the structural units A; and c) a molecular weight in the range from 500 to 10000 Daltons.



COATING COMPOSITION

The present invention relates to an aqueous coating composition comprising a carboxylic acid functional polymer in an aqueous medium and further
5 comprising a multi-aziridine compound. The present invention further relates to the use of such coating composition as a one-pack coating system.

Coatings provide protection, aesthetic quality and new functionality to a wide range of substrates with tremendous industrial and household relevance. In this context, the need for coatings with improved resistances, like stain and solvent
10 resistance, improved mechanical properties and improved adhesive strength is growing continuously. One or more of those properties can be enhanced by means of crosslinking. Many crosslinking mechanisms for polymeric binders have been studied over the years and for waterborne latex polymer dispersions, the most useful ones include isocyanate crosslinking of hydroxyl functional polymers, carbodiimide
15 crosslinking of carboxylic acid functional polymers, melamine crosslinking, epoxy crosslinking and aziridine crosslinking of carboxylic acid functional polymers.

Waterborne binders are generally colloidal stabilized by carboxylic acid groups, and the coating properties can be improved by the use of carbodiimide or aziridine crosslinkers since they react with the carboxylic acid
20 moieties of the polymer resulting in a crosslinked network. Of the state-of-the-art crosslinkers as mentioned above, aziridine crosslinkers are most versatile for room temperature curing of carboxylic acid functional polymers.

Traditional crosslinking approaches generally involve the use of reactive organic molecules of low molecular weight, to achieve high crosslinking
25 densities. Upon addition to waterborne binders, these reactive molecules commonly display immediate reaction with carboxylate-functional binders, as well as side reactions with for example water, resulting in a limited application window of the coating composition. As a result, these so-called 2K coating systems require users to mix crosslinker and binder just before application, incurring additional effort and cost.
30 It would therefore be beneficial to deliver waterborne 1K coating systems, comprising the binder to be crosslinked as well as the crosslinker, with good crosslinking efficiency and with a long shelf life.

Multi-aziridine crosslinkers are most versatile for room temperature curing of carboxylic acid functional polymers. However, current state-of-the-art multi-
35 aziridine crosslinkers such as for example described in US-A-5133997 lack stability

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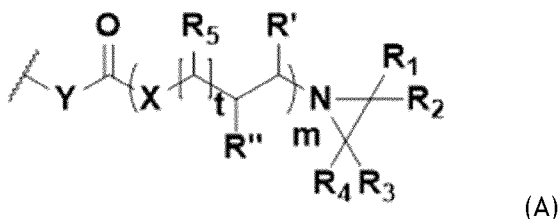
when combined with these polymers. For example, CX-100 (trimethylolpropane tris(2-methyl-1-aziridinepropionate; CAS number 64265-57-2) and XAMA-7 (pentaerythritol tris[3-(1-aziridinyl)propionate; CAS No. 57116-45-7) are unsuitable for use in 1K systems, because their homogeneous distribution throughout the resin matrix makes them susceptible to nucleophilic species, such as water or carboxylate species. Additionally, these crosslinkers are hazardous materials, precluding their use outside professional and well controlled environments. Additionally, these polyaziridines have an unfavourable genotoxic profile.

State-of-the-art 1K systems, for example using keto-amine or silane condensation chemistries, provide lower performance due to reduced reactivity. Additionally, these crosslinking methodologies require the incorporation of specific functional monomers into the polymer backbone, adding cost and reducing compositional freedom. For many existing 1K systems, increasing the temperature or another external trigger is required to start cure after film application, further adding to practical complexity. Self-crosslinkable coating compositions are crosslinkable without the requirement for mixing reactive materials just prior to application which react with groups on the crosslinkable polymer, although such external triggers can still be employed if desired.

The object of the present invention is to provide an aqueous coating composition comprising a multi-aziridine compound and a carboxylic acid functional polymer with good crosslinking efficiency and a longer shelf-life.

This object has surprisingly been achieved by an aqueous dispersion having a pH ranging from 8 to 14, wherein the aqueous dispersion comprises multi-aziridine compound particles X in dispersed form and carboxylic acid functional polymer particles Y in dispersed form, and said multi-aziridine compound has:

a) from 2 to 6 of the following structural units A:



whereby

30 R₁ is H,

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R₂ and R₄ are independently chosen from H or an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,

R₃ is an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,

m is an integer from 1 to 6,

5 R' and R'' are according to (1) or (2):

(1) R' = H or an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, and

10 R'' = H, an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, a cycloaliphatic hydrocarbon group containing from 5 to 12 carbon atoms, an aromatic hydrocarbon group containing from 6 to 12 carbon atoms, CH₂-O-(C=O)-R''', CH₂-O-R''', or CH₂-(OCR''''HCR''''H)_n-OR''''', whereby R''' is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms and R'''' is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms or an aromatic hydrocarbon group containing from 6 to 12 carbon atoms, n being from 1 to 35, R'''' independently being H or an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms and R'''''' being an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,

20 (2) R' and R'' form together a saturated cycloaliphatic hydrocarbon group containing from 5 to 8 carbon atoms,

t is an integer from 0 to 3,

R₅ is H or CH₃,

X and Y are according to (I), (II) or (III):

25 (I) X and Y are both N-R₆;

(II) X is O and Y is N-R₆;

(III) X is N-R₆ and Y is O,

whereby R₆ is H or a linear or branched hydrocarbon group containing 1 to 4 carbon atoms;

30 b) one or more linking chains wherein each one of these linking chains links two of the structural units A; and

c) a molecular weight in the range from 500 to 10000 Daltons.

35

It has surprisingly been found that the aqueous coating composition of the present invention has prolonged storage-stability, while at the same time also showing a good crosslinking efficiency upon drying of the aqueous coating composition. The compositions according to the invention shows efficient crosslinking reaction at room temperature. The compositions of the invention are also easy to use, providing a one-pot solution for facile storage, handling and application.

Accordingly, the aqueous coating compositions according to the invention can provide self-crosslinkable compositions which can be applied as one-pack coating systems without the necessity of mixing reactive materials just prior to application as in a two-pack coating system. The stability of the coating composition of the invention and the improved properties of the corresponding dried film, combined with a favorable hazard profile, generate a high-performance 1K system. This 1K system, wherein crosslinking is triggered only upon coating application, is very accessible to a range of coating applicators, since it reduces handling of hazardous materials and provides good coating properties.

US-A-3523750 describes a process for modifying proteinaceous substrates such as wool with a multi-aziridine compound. US-A-5258481 describes multifunctional water-dispersible crosslink agents which is an oligomeric material containing carbodiimide functionalities and reactive functional groups which are different from said carbodiimide functional group. US-A-5241001 discloses multi-aziridine compounds obtained by the reaction of 1-(2-hydroxyethyl)-ethyleneimine with a polyisocyanate.

For all upper and/or lower boundaries of any range given herein, the boundary value is included in the range given, unless specifically indicated otherwise. Thus, when saying from x to y, means including x and y and also all intermediate values.

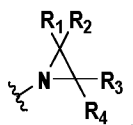
The term "coating composition" encompasses, in the present description, paint, coating, varnish, adhesive and ink compositions, without this list being limiting. The term "aliphatic hydrocarbon group" refers to optionally branched alkyl, alkenyl and alkynyl group. The term "cycloaliphatic hydrocarbon group" refers to cycloalkyl and cycloalkenyl group optionally substituted with at least one aliphatic hydrocarbon group. The term "aromatic hydrocarbon group" refers to a benzene ring optionally substituted with at least one aliphatic hydrocarbon group. These optional aliphatic hydrocarbon group substituents are preferably alkyl groups. Examples of cycloaliphatic hydrocarbon groups with 7 carbon atoms are cycloheptyl and methyl

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substituted cyclohexyl. An example of an aromatic hydrocarbon group with 7 carbon atoms is methyl substituted phenyl. Examples of aromatic hydrocarbon groups with 8 carbon atoms are xylyl and ethyl substituted phenyl.

An aziridiny group has the following structural formula:

5



Multi-aziridine compound

10 R_1 is H. R_2 and R_4 are independently chosen from H or an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms. Preferably, R_2 and R_4 are independently chosen from H or an aliphatic hydrocarbon group containing from 1 to 2 carbon atoms.

15 R_3 is an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms, preferably an aliphatic hydrocarbon group containing from 1 to 2 carbon atoms.

In a preferred embodiment of the invention, R_2 is H, R_3 is an aliphatic hydrocarbon group containing from 1 to 2 carbon atoms and R_4 is H.

20 In a more preferred embodiment of the invention, R_2 is H, R_3 is C_2H_5 and R_4 is H. In another embodiment of the invention, R_2 is H, R_3 is CH_3 and R_4 is H or CH_3 . In another and even more preferred embodiment of the invention, R_2 is H, R_3 is CH_3 and R_4 is H.

25 Whilst the structural units A present in the multi-aziridine compound may independently have different R' , R'' , R_1 , R_2 , R_2 , R_4 , R_5 , X, Y, t and/or m, the structural units A present in the multi-aziridine compound are preferably identical to each other.

m is an integer from 1 to 6, preferably m is from 1 to 4, more preferably m is 1 or 2 and most preferably m is 1.

t is an integer from 0 to 3, more preferably t is 0 or 1.

30

Preferably, R' and R'' are according to (1) or (2):

- (1) $R' = H$ or an alkyl group containing from 1 to 2 carbon atoms;
 $R'' = H$, an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms, $CH_2-O-(C=O)-R'''$, or CH_2-O-R''' , whereby R''' is an alkyl group containing

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from 1 to 14 carbon atoms and R^{'''} is an alkyl group containing from 1 to 14 carbon atoms, n being from 1 to 35, R^{''''} independently being H or a methyl group and R^{'''''} being an alkyl group containing from 1 to 4 carbon atoms;

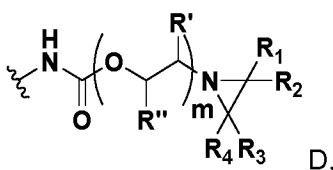
- (2) R['] and R^{''} form together a saturated cycloaliphatic hydrocarbon group containing from 5 to 8 carbon atoms.

In a preferred embodiment of the invention, R₂ is H, R₃ is an aliphatic hydrocarbon group containing from 1 to 2 carbon atoms, R₄ is H, m is 1, t is 0, X is O, Y is NH, R['] is H and R^{''} is H, an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, a cycloaliphatic hydrocarbon group containing from 5 to 12 carbon atoms, an aromatic hydrocarbon group containing from 6 to 12 carbon atoms, CH₂-O-(C=O)-R^{'''} or CH₂-O-R^{''''}, whereby R^{'''} is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, preferably R^{'''} is an aliphatic hydrocarbon group containing from 3 to 12 carbon atoms and R^{''''} is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms. More preferably, R['] is H and R^{''} is an alkyl group containing from 1 to 4 carbon atoms, CH₂-O-(C=O)-R^{'''}, CH₂-O-R^{''''}, whereby R^{'''} is an alkyl group containing from 3 to 12 carbon atoms, such as for example neopentyl or neodecyl. Most preferably R^{'''} is a branched C₉ alkyl. R^{''''} is preferably an alkyl group containing from 1 to 14 carbon atoms, more preferably from 1 to 12 carbon atoms. Non-limited examples for R^{''''} are ethyl, butyl and 2-ethylhexyl.

R₅ is H or CH₃.

R₆ is H or a linear or branched hydrocarbon group containing from 1 to 4 carbon atoms, preferably R₆ is H

The multi-aziridine compound preferably has from 2 to 6 of the following structural units D:



whereby R₁, R₂, R₃, R₄, R['], R^{''} and m and its preferments are as defined above.

Thus structural units A present in the multi-aziridine compound are preferably according to structural formula D.

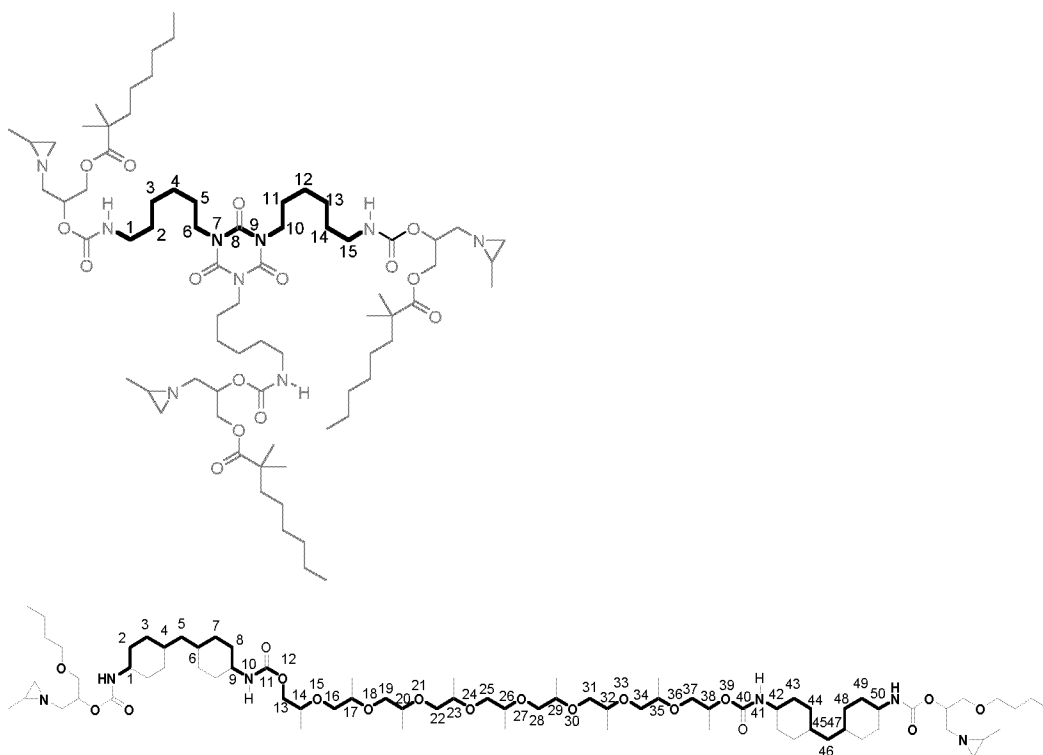
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The multi-aziridine compound contains from 2 to 6 of the structural units A, preferably from 2 to 4 of the structural units A, more preferably 2 or 3 structural units A.

The multi-aziridine compound comprises one or more linking chains wherein each one of these linking chains links two of the structural units A. The linking chains present in the multi-aziridine compound preferably consist of from 4 to 300 atoms, more preferably from 5 to 250 and most preferably from 6 to 100 atoms. The atoms of the linking chains are preferably C and optionally N, O, S and/or P, preferably C and optionally N and/or O. The linking chains present in the multi-aziridine compound preferably consist of from 4 to 300 atoms, more preferably from 5 to 250, more preferably from 6 to 100 atoms and most preferably from 6 to 20 atoms. The linking chains are preferably a collection of atoms covalently connected which collection of atoms consists of i) carbon atoms, ii) carbon and nitrogen atoms, or iii) carbon, oxygen and nitrogen atoms.

15

A linking chain is defined as the shortest chain of consecutive atoms that links two structural units A. The following drawings show examples of multi-aziridine compounds, and the linking chains between two structural units A.



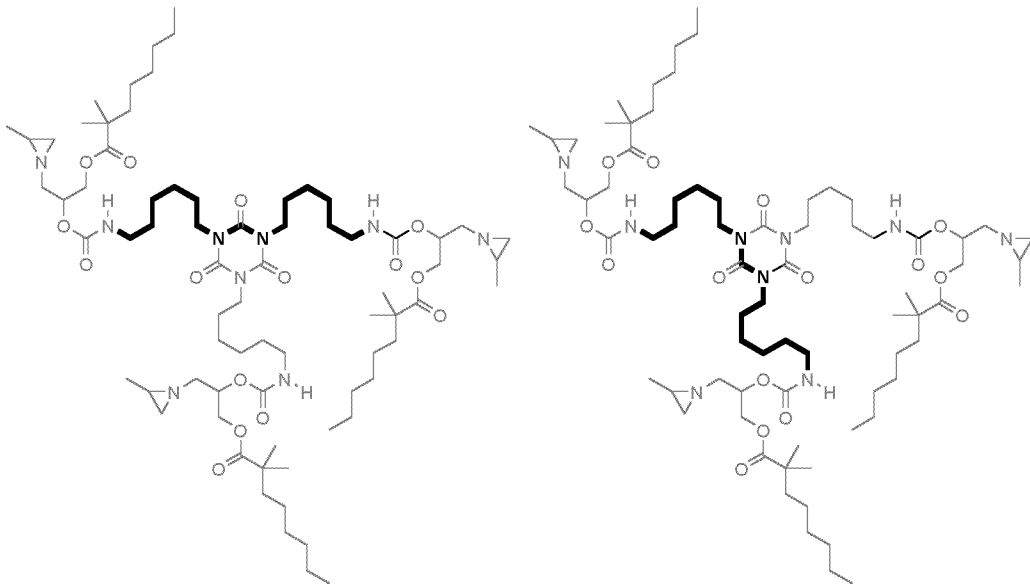
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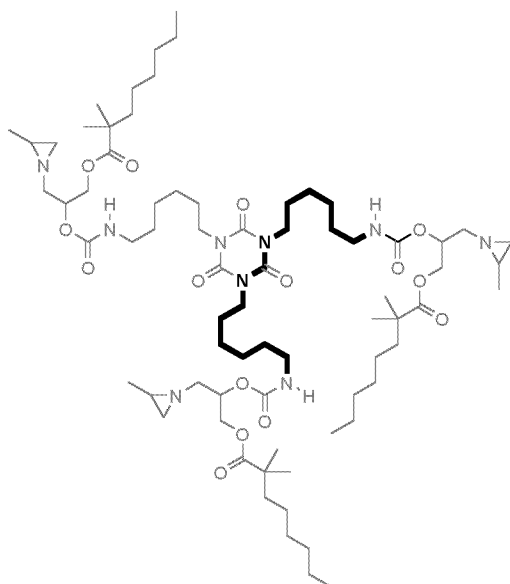
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Any two of the structural units A present in the multi-aziridine compound are linked via a linking chain as defined herein. Accordingly, each structural unit A present in the multi-aziridine compound is linked to every other structural unit A via a linking chain as defined herein. In case the multi-aziridine compound has two structural units A, the multi-aziridine compound has one such linking chain linking these two structural units.

In case the multi-aziridine compound has three structural units A, the multi-aziridine compound has three linking chains, whereby each of the three linking chains is linking a structural unit A with another structural unit A, i.e. a first structural unit A is linked with a second structural unit A via a linking chain and the first and second structural units A are both independently linked with a third structural unit A via their respective linking chains.

The following drawings show for an example of a multi-aziridine compound having three structural units A, the three linking chains whereby each one of the three linking chains links two structural units A.





Multi-aziridine compounds with more than two structural units A have a number of linking chains according to the following equation:

$LC = \{(AN-1) \times AN\} / 2$, whereby LC= the number of linking chains and AN = the

- 5 number of structural units A in the multi-aziridine compound. So for example if there are 5 structural units A in the multi-aziridine compound, AN = 5; which means that there are $\{(5-1) \times 5\} / 2 = 10$ linking chains.

- The molecular weight of the multi-aziridine compound is preferably from 600 to 5000 Daltons. The molecular weight of the multi-aziridine compound is preferably
- 10 at most 3800 Daltons, more preferably at most 3600 Daltons, more preferably at most 3000 Daltons, more preferably at most 1600 Daltons, even more preferably at most 1400 Daltons. The molecular weight of the multi-aziridine compound is preferably at least 700 Daltons, more preferably at least 800 Daltons, even more preferably at least
- 15 840 Daltons and most preferably at least 1000 Daltons. As used herein, the molecular weight of the multi-aziridine compound is the calculated molecular weight. The calculated molecular weight is obtained by adding the atomic masses of all atoms present in the structural formula of the multi-aziridine compound. If the multi-aziridine compound is present in a composition comprising more than one multi-aziridine compound according to the invention, for example when one or more of the starting
- 20 materials to prepare the multi-aziridine compound is a mixture, the molecular weight calculation can be performed for each compound individually present in the composition. The molecular weight of the multi-aziridine compound according to the

invention can be measured using MALDI-TOF mass spectrometry as described in the experimental part below.

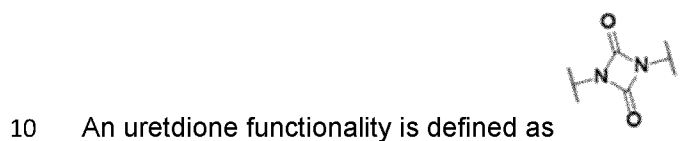
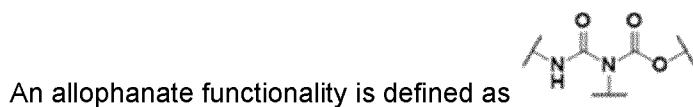
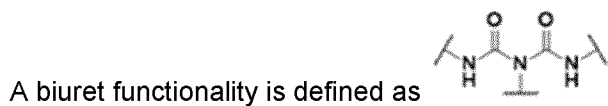
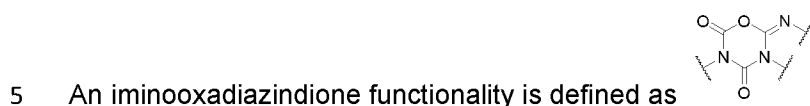
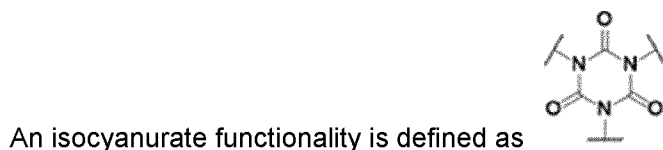
The multi-aziridine compound preferably comprises one or more connecting groups, whereby each one of these connecting groups connects two of the structural units A and whereby each one of these connecting groups consists of at least one functionality selected from the group consisting of aliphatic hydrocarbon functionality (preferably containing from 1 to 8 carbon atoms), cycloaliphatic hydrocarbon functionality (preferably containing from 4 to 10 carbon atoms), aromatic hydrocarbon functionality (preferably containing from 6 to 12 carbon atoms), isocyanurate functionality, iminooxadiazindione functionality, ether functionality, ester functionality, amide functionality, carbonate functionality, urethane functionality, urea functionality, biuret functionality, allophanate functionality, uretdione functionality and any combination thereof. More preferably, the connecting groups are an array of consecutive functionalities whereby each functionality is selected from the group consisting of aliphatic hydrocarbon functionality (preferably containing from 1 to 8 carbon atoms), cycloaliphatic hydrocarbon functionality (preferably containing from 4 to 10 carbon atoms), aromatic hydrocarbon functionality (preferably containing from 6 to 12 carbon atoms), isocyanurate functionality, iminooxadiazindione functionality, ether functionality, ester functionality, amide functionality, carbonate functionality, urethane functionality, urea functionality, biuret functionality, allophanate functionality, uretdione functionality.

The term "aliphatic hydrocarbon functionality" refers to optionally branched alkyl, alkenyl and alkynyl groups. Whilst the optional branches of C atoms are part of the connecting group, they are not part of the linking chain.

The term "cycloaliphatic hydrocarbon functionality" refers to cycloalkyl and cycloalkenyl groups optionally substituted with at least one aliphatic hydrocarbon group. Whilst the optional aliphatic hydrocarbon group substituents are part of the connecting group, they are not part of the linking chain. The optional aliphatic hydrocarbon group substituents are preferably alkyl groups.

The term "aromatic hydrocarbon functionality" refers to a benzene ring optionally substituted with at least one aliphatic hydrocarbon group. Whilst the optional aliphatic hydrocarbon group substituents are part of the connecting group, they are not part of the linking chain. The optional aliphatic hydrocarbon group substituents are preferably alkyl groups.

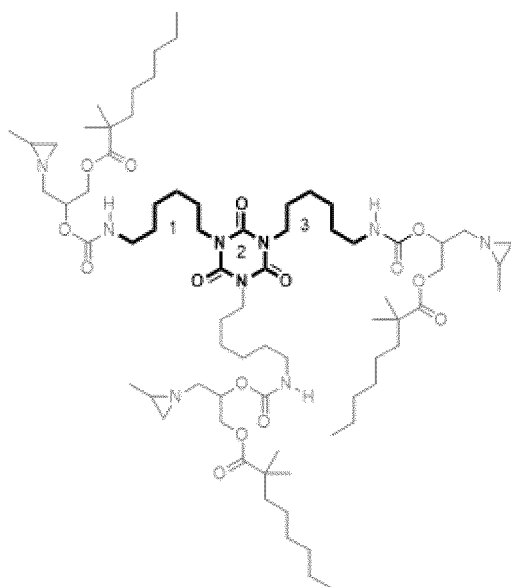
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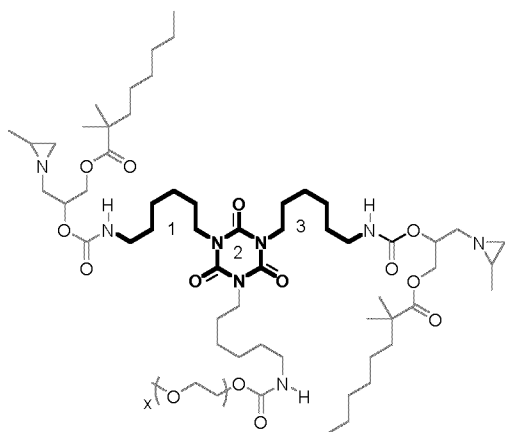
The following drawing shows in bold a connecting group for an example of a multi-aziridine compound as defined herein. In this example, the connecting group connecting two of the structural units A consists of the array of the following

15 consecutive functionalities: aliphatic hydrocarbon functionality 1 (a linear C₆H₁₂), isocyanurate 2 (a cyclic C₃N₃O₃) functionality and aliphatic hydrocarbon functionality 3 (a linear C₆H₁₂).

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- The following drawing shows in bold the connecting group for the following example of a multi-aziridine compound as defined herein. In this example, the connecting group connecting the two structural units A consists of the array of the following
- 5 consecutive functionalities: aliphatic hydrocarbon functionality 1 (a linear C_6H_{12}), isocyanurate 2 (a cyclic $C_3N_3O_3$) and aliphatic hydrocarbon functionality 3 (a linear C_6H_{12}).

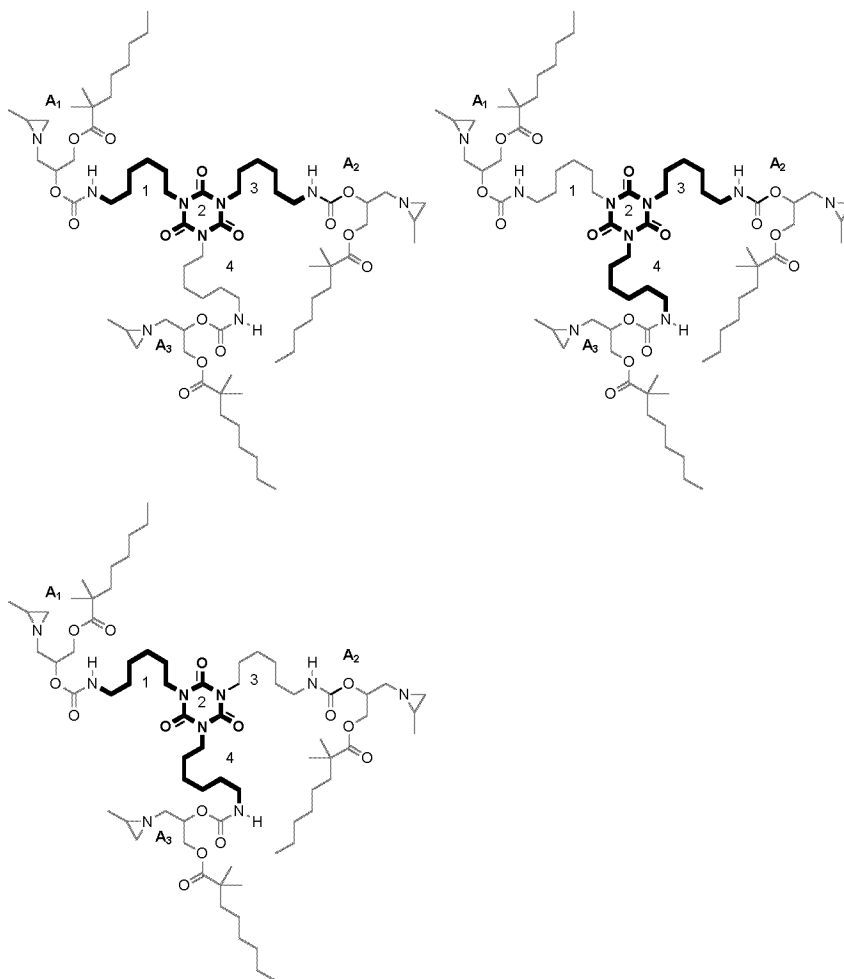


- 10 Any two of the structural units A present in the multi-aziridine compound as defined herein are preferably connected via a connecting group which connecting group is as defined herein. Accordingly, each structural unit A present in the multi-

aziridine compound is preferably connected to every other structural unit A with a connecting group which connecting group is as defined in the invention. In case the multi-aziridine compound has two structural units A, the multi-aziridine compound has one such connecting group connecting these two structural units. In case the multi-aziridine compound has three structural units A, the multi-aziridine compound has three such connecting groups, whereby each one of the three connecting groups is connecting a structural unit A with another structural unit A.

The following drawing shows, for an example of a multi-aziridine compound having three structural units A, the three connecting groups whereby each one of the three connecting groups is connecting two structural units A. One connecting group consists of the array of the following consecutive functionalities: aliphatic hydrocarbon functionality 1 (a linear C_6H_{12}), isocyanurate 2 (a cyclic $C_3N_3O_3$) and aliphatic hydrocarbon functionality 3 (a linear C_6H_{12}) connecting the structural units A which are labelled as A1 and A2. For the connection between structural units A which are labelled as A1 and A3, the connecting group consists of the array of the following consecutive functionalities: aliphatic hydrocarbon functionality 1 (a linear C_6H_{12}), isocyanurate 2 (a cyclic $C_3N_3O_3$) and aliphatic hydrocarbon functionality 4 (a linear C_6H_{12}), while for the connection between the structural units A which are labelled as A2 and A3, the connecting group consists of the array of the following consecutive functionalities: aliphatic hydrocarbon functionality 3 (a linear C_6H_{12}), isocyanurate 2 (a cyclic $C_3N_3O_3$) and aliphatic hydrocarbon functionality 4 (a linear C_6H_{12}).

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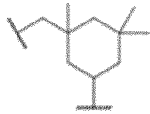


- Preferably, the connecting groups consist of at least one functionality
- 5 selected from the group consisting of aliphatic hydrocarbon functionality (preferably containing from 1 to 8 carbon atoms), cycloaliphatic hydrocarbon functionality (preferably containing from 4 to 10 carbon atoms), aromatic hydrocarbon functionality (preferably containing from 6 to 12 carbon atoms), isocyanurate functionality, iminoxadiazindione functionality, urethane functionality, urea functionality, biuret
- 10 functionality and any combination thereof. The connecting groups preferably contain an isocyanurate functionality, an iminoxadiazindione functionality, a biuret functionality, allophanate functionality or an uretdione functionality. More preferably, the connecting groups contain an isocyanurate functionality or an iminoxadiazindione functionality. For the sake of clarity, the multi-aziridine
- 15 compound may be obtained from the reaction product of one or more suitable compound B as defined herein below and a hybrid isocyanurate such as for example

- 15 -

a HDI/IPDI isocyanurate, resulting in a multi-aziridine compound with a connecting group consisting of the array of the following consecutive functionalities: a linear C_6H_{12} (i.e. an aliphatic hydrocarbon functionality with 6 carbon atoms), an isocyanurate functionality (a cyclic $C_3N_3O_3$) and

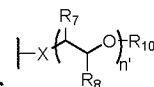
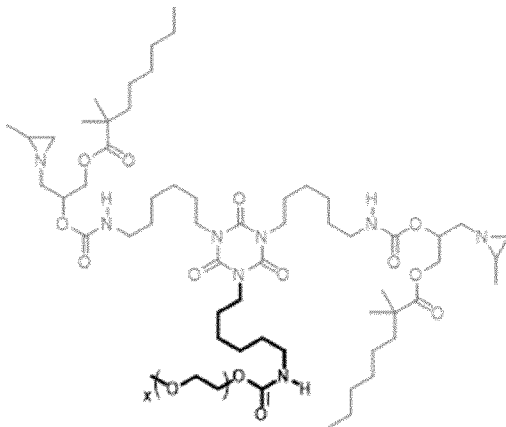
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(i.e. a cycloaliphatic hydrocarbon functionality with 9 carbon atoms and an aliphatic hydrocarbon functionality with 1 carbon atom). Even more preferably, the connecting groups consist of the following functionalities : at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality, and further
10 an isocyanurate functionality or an iminooxadiazindione functionality.

On the connecting groups, one or more substituents may be present as pendant groups on the connection group, as shown in bold in for example the following multi-aziridine compound. These pendant groups are not part of the connecting groups.

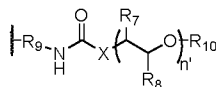
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The pendant group preferably contains $\left[\text{X} - \text{C}(\text{R}_7) - \text{C}(\text{R}_8) - \text{O} - \text{C}(\text{R}_{10}) \right]_{n'}$, in which X, R_7 , R_8 , n' and R_{10} are as described below. In an embodiment of the invention, the multi-aziridine compound comprises one or more connecting groups wherein each one of these connecting groups connects two of the structural units A, wherein the connecting
20 groups consist of (i) at least two aliphatic hydrocarbon functionality or at least two cycloaliphatic hydrocarbon functionality and (ii) an isocyanurate functionality or an

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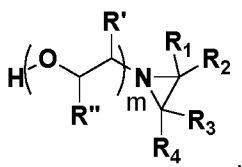
iminoxadiazindione functionality, and wherein a pendant group is present on a connecting group, whereby the pendant group has the following structural formula :



- 5 n' is the number of repeat units and is an integer from 1 to 50, preferably from 2 to 30, more preferably from 5 to 20.
 X is O or NH, preferably X is O,
 R_7 and R_8 are independently H or CH_3 in each repeating unit,
- R_9 is an aliphatic hydrocarbon group, preferably containing from 1 to 8 carbon atoms,
 10 or a cycloaliphatic hydrocarbon group, preferably containing from 4 to 10 carbon atoms, and
- R_{10} contains at most 20 carbon atoms and is an aliphatic, cycloaliphatic or aromatic hydrocarbon group or a combination thereof. In a preferred embodiment, R_7 and R_8 are H. In another and more preferred embodiment, one of R_7 and R_8 is H and the
 15 other R_7 or R_8 is CH_3 . R_{10} preferably is an aliphatic hydrocarbon group containing from 1 to 20 carbon atoms (preferably CH_3), a cycloaliphatic hydrocarbon group containing from 5 to 20 carbon atoms or an aromatic hydrocarbon group containing from 6 to 20 carbon atoms. The presence of the pendant group results in a
 20 decreased viscosity of the multi-aziridine compound and hence easier dispersibility in the aqueous medium. In this embodiment, the multi-aziridine compound preferably contains 2 structural units A. In this embodiment the connecting group preferably consists of the array of the following consecutive functionalities: a first cycloaliphatic hydrocarbon functionality, an isocyanurate functionality or an iminoxadiazindione functionality, and a second cycloaliphatic hydrocarbon functionality, and R_9 is a
 25 cycloaliphatic hydrocarbon group, whereby the first and second cycloaliphatic hydrocarbon functionality and R_9 are identical, more preferably the connecting group consists of the array of the following consecutive functionalities: a first aliphatic hydrocarbon functionality, an isocyanurate functionality or an iminoxadiazindione functionality, and a second aliphatic hydrocarbon functionality, and R_9 is an aliphatic
 30 hydrocarbon group, whereby the first and second aliphatic hydrocarbon functionality and R_9 are identical.

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In a preferred embodiment of the invention, the connecting groups present in the multi-aziridine compound as defined herein consist of the following functionalities: (i) at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality and (ii) optionally at least one aromatic hydrocarbon functionality and (iii) optionally an isocyanurate functionality or iminooxadiazindione functionality or allophanate functionality or uretdione functionality. Preferably, the connecting groups present in the multi-aziridine compound of the invention consist of the following functionalities: (i) at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality and (ii) optionally at least one aromatic hydrocarbon functionality and (iii) optionally an isocyanurate functionality or iminooxadiazindione functionality. A very suitable way of obtaining such multi-aziridine compound is reacting compound B with the following structural formula:



with a polyisocyanate with aliphatic reactivity. The term “a polyisocyanate with aliphatic reactivity” being intended to mean compounds in which all of the isocyanate groups are directly bonded to aliphatic or cycloaliphatic hydrocarbon groups, irrespective of whether aromatic hydrocarbon groups are also present. The polyisocyanate with aliphatic reactivity can be a mixture of polyisocyanates with aliphatic reactivity. Compounds based on polyisocyanate with aliphatic reactivity have a reduced tendency of yellowing over time when compared to a similar compound but based on polyisocyanate with aromatic reactivity. The term “a polyisocyanate with aromatic reactivity” being intended to mean compounds in which all of the isocyanate groups are directly bonded to a benzene or a naphthalene group, irrespective of whether aliphatic or cycloaliphatic groups are also present. Preferred polyisocyanates with aliphatic reactivity are 1,5-pentamethylene diisocyanate PDI, 1,6-hexamethylene diisocyanate HDI, isophorone diisocyanate IPDI, 4,4'-dicyclohexyl methane diisocyanate H12MDI, 2,2,4-trimethyl hexamethylene diisocyanate, 2,4,4-trimethyl hexamethylene diisocyanate, tetramethylxylene diisocyanate TMXDI (all isomers) and higher molecular weight variants like for example their isocyanurates, or iminooxadiazindiones. In this embodiment, preferably the connecting groups consist of the array of the following consecutive functionalities: aliphatic hydrocarbon

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functionality, aromatic hydrocarbon functionality and aliphatic hydrocarbon functionality (for example when using TMXDI for preparing the multi-aziridine compound) or the connecting groups consist of the array of the following consecutive functionalities: cycloaliphatic hydrocarbon functionality, aliphatic hydrocarbon

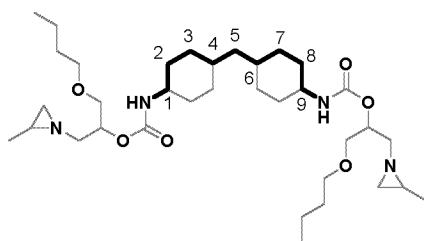
5 functionality and cycloaliphatic hydrocarbon functionality (for example when using H12MDI for preparing the multi-aziridine compound) or more preferably, the connecting groups consist of the array of the following consecutive functionalities: aliphatic hydrocarbon functionality, isocyanurate functionality or iminoxadiazindione functionality, and aliphatic hydrocarbon functionality. Most preferably, in this

10 embodiment, the connecting group consists of the array of the following consecutive functionalities: aliphatic hydrocarbon functionality, isocyanurate functionality, and aliphatic hydrocarbon functionality (for example when using an isocyanurate of 1,6-hexamethylene diisocyanate and/or an isocyanurate of 1,5-pentamethylene diisocyanate for preparing the multi-aziridine compound).

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Preferably, the number of consecutive C atoms and optionally O atoms between the N atom of the urethane group in a structural unit D and the next N atom which is either present in the linking chain or which is the N atom of the urethane group of another structural unit D is at most 9, as shown in for example the following

20 multi-aziridine compounds having 2 resp. 3 structural units D.



or a bismuth catalyst such as for example bismuth neodecanoate. A solvent may be used, such as for example dimethylformamide DMF, acetone and/or methyl ethyl ketone. The polyisocyanate contains at least 2 isocyanate groups, preferably at least 2.5 isocyanate groups on average and more preferably at least 2.8 isocyanate groups on average. Mixtures of polyisocyanates may also be used as starting materials. Preferred polyisocyanates are polyisocyanates with aliphatic reactivity. The term "a polyisocyanate with aliphatic reactivity" being intended to mean compounds in which all of the isocyanate groups are directly bonded to aliphatic or cycloaliphatic hydrocarbon groups, irrespective of whether aromatic hydrocarbon groups are also present. The polyisocyanate with aliphatic reactivity can be a mixture of polyisocyanates with aliphatic reactivity. Preferred polyisocyanates with aliphatic reactivity are 1,5-pentamethylene diisocyanate PDI, 1,6-hexamethylene diisocyanate HDI, isophorone diisocyanate IPDI, 4,4'-dicyclohexyl methane diisocyanate H12MDI, 2,2,4-trimethyl hexamethylene diisocyanate, 2,4,4-trimethyl hexamethylene diisocyanate, p-tetra-methylxylene diisocyanate (p-TMXDI) and its meta isomer, and higher molecular weight variants like for example their isocyanurates or iminooxadiazindiones or allophanates or uretdiones. More preferred polyisocyanates with aliphatic reactivity are 4,4'-dicyclohexyl methane diisocyanate H12MDI, m-TMXDI, an isocyanurate or iminooxadiazindione or allophanate or uretdione of 1,6-hexamethylene diisocyanate and an isocyanurate of 1,5-pentamethylene diisocyanate. A suitable HDI containing iminooxadiazindione trimer is Desmodur® N3900, obtainable from Covestro. A suitable HDI containing allophanate is Desmodur® XP2860, obtainable from Covestro. A suitable HDI containing uretdione is Desmodur® N3400, obtainable from Covestro. Suitable HDI based isocyanurates trimers can for example be obtained from Covestro (Desmodur® N3600), Vencorex (Tolonate™ HDT LV), Asahi Kasei (Duramate™ TPA-100), Evonik (Vestanat® HT 2500/LV) and Tosoh (Coronate® HXR LV). Methods for preparing compound (B) and derivatives are known in the art. For example, synthesis of 1-(2-methylaziridin-1-yl)propan-2-ol is described by S. Lesniak, M. Rachwalski, S. Jarzynski, E. Obijalska *Tetrahedron Asymm.* **2013**, *24* 1336-1340. Synthesis of 1-(aziridin-1-yl)propan-2-ol is described by A. Baklien, M. V. Leeding, J. Kolm *Aust. J. Chem.* **1968**, *21*, 1557-1570. Preferred aziridine compounds used for preparing compound B are propylene imine and ethylaziridine. Synthesis of ethylaziridine is for example described in EP0227461B1. Most preferred aziridine compounds used for preparing compound B is propylene imine.

The multi-aziridine compound can also be obtained by reacting at least a compound B with a polyisocyanate as defined above and a polyol and/or a polyamine. The multi-aziridine compound can also be obtained by reacting the polyisocyanate as defined above with a polyol and/or a polyamine and reacting the

5 so-obtained compound with compound B. The multi-aziridine compound can also be obtained by reacting compound B with the polyisocyanate and reacting the so obtained compound with a polyol and/or a polyamine. The multi-aziridine compound can also be obtained by reacting at least a compound B with an isocyanate terminated polyurethane and/or a polyurethane urea. The (isocyanate terminated)

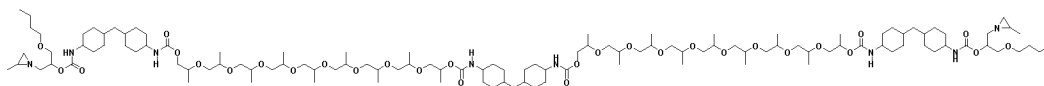
10 polyurethane (urea) is obtained by reacting at least one polyol and/or polyamine with at least one polyisocyanate. Preferred polyisocyanates are as described above. The polyol is preferably selected from the group consisting of polyether polyols, polyester polyols, polythioether polyols, polycarbonate polyols, polyacetal polyols, polyvinyl polyols, polysiloxane polyols and any mixture thereof. More preferably the polyol is

15 selected from the group consisting of polyether polyols and any mixture thereof. Preferred polyether polyols are polytetrahydrofuran, polyethylene oxide, polypropylene oxide or any mixture thereof. More preferred polyether polyols are alkoxy poly(propyleneglycol) (preferably methoxy poly(propyleneglycol)), poly(propyleneglycol) and any mixture thereof. The amount of polyoxyethylene (-O-

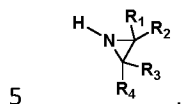
20 CH₂-CH₂)_x, polyoxypropylene (-O-CHCH₃-CH₂)_x or (-O-CH₂-CH₂-CH₂-)_x group(s) and/or polytetrahydrofurane (-O-CH₂-CH₂-CH₂-CH₂)_x groups in the multi-aziridine compound is preferably at least 6 wt.%, more preferably at least 10 wt.% and preferably less than 45wt.%, more preferably less than 40 wt.% and most preferably less than 35 wt.%, relative to the multi-aziridine compound. x represents an average

25 addition mole number of oxyethylene, oxypropylene resp. tetrahydrofurane and x is preferably an integer from 5 to 20. The polyamine is preferably selected from the group consisting of polyether polyamines, polyester polyamines, polythioether polyamines, polycarbonate polyamines, polyacetal polyamines, polyvinyl polyamines, polysiloxane polyamines and any mixture thereof. More preferably the polyamine is

30 selected from the group consisting of polyether polyamines and any mixture thereof. Preferred polyether polyamines are Jeffamine® D-230, Jeffamine® D-400 and Jeffamine® D-2000. The use of a polyol is preferred over the use of a polyamine. An example of such a multi-aziridine compound is shown below:



Compound B is preferably obtained by reacting at least a non-OH functional monoepoxide compound with an aziridine compound with the following structural formula (E):



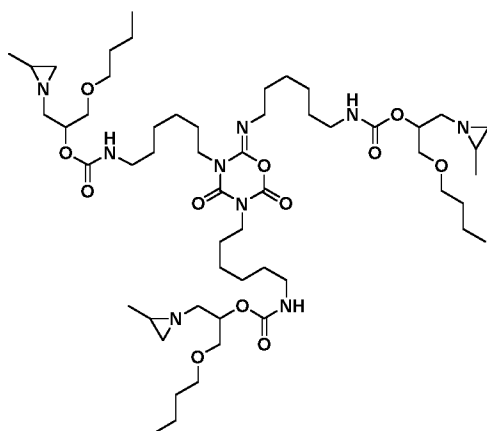
whereby R₁, R₂, R₃ and R₄ are as defined above. The non-OH functional monoepoxide may be a mixture of different non-OH functional monoepoxides. Non-limited examples of non-OH functional monoepoxide are ethylene oxide, propylene oxide, 2-ethyl oxirane, n-butylglycidylether, 2-ethylhexylglycidylether, phenyl glycidyl ether, 4-*tert*-butylphenyl 2,3-epoxypropyl ether (= *t*-butyl phenyl glycidyl ether), cresol glycidyl ether (ortho or para) and glycidyl neodecanoate. The non-OH functional monoepoxide is preferably selected from the group consisting of ethylene oxide (CAS number 75-21-8), propylene oxide (CAS number 75-56-9), 2-ethyl oxirane (CAS number 106-88-7), n-butylglycidylether (CAS number 2426-08-6), 2-ethylhexylglycidylether (CAS number 2461-15-6), glycidyl neodecanoate (CAS number 26761-45-5) and any mixture thereof. More preferably, the non-OH functional monoepoxide is selected from the group consisting of propylene oxide (CAS number 75-56-9), 2-ethyl oxirane (CAS number 106-88-7), n-butylglycidylether (CAS number 2426-08-6), 2-ethylhexylglycidylether (CAS number 2461-15-6), glycidyl neodecanoate (CAS number 26761-45-5) and any mixture thereof.

The multi-aziridine compound is preferably obtained in a process comprising at least the following steps (i) and (ii):

- (i) Reacting an aziridine of formula (E) with at least a non-OH functional monoepoxide compound to obtain compound B, and
- (ii) Reacting compound B with a polyisocyanate.

Step (i) can be carried out, for example, by bringing one equivalent of the epoxide compound into contact with one equivalent of the aziridine at a temperature in the range of from 20 °C to 110 °C, more suitable from 40 °C to 95 °C, even more suitable from 60 to 85 °C at atmospheric pressure. The reaction (step (ii)) of the adduct (compound B) obtained in step (i) with the polyisocyanate can be carried out, for example, by bringing equivalent amounts of the polyisocyanate into

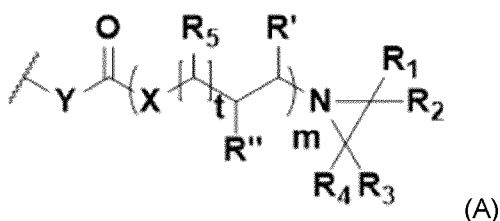
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In a preferred embodiment of the invention, the multi-aziridine compound present in dispersed form in the aqueous coating composition of the invention has

a. from 2 to 6 the structural units according to structural formula A



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whereby R_1 , R_2 , R_3 , R_4 , R_5 , R' , R'' , X , Y , m and t and its preferences are as defined above,

b. one or more linking chains wherein each one of these linking chains links two of the structural units A, whereby the one or more linking chains are preferably as defined above, and

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c. a molecular weight from 600 to 5000 Daltons, preferably a molecular weight of at least 700 Daltons, more preferably at least 800 Daltons, even more preferably at least 840 Daltons and most preferably at least 1000 Daltons and

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preferably a molecular weight of at most 3800 Daltons, more preferably at most 3600 Daltons, more preferably at most 3000 Daltons, more preferably at most 1600 Daltons, even more preferably at most 1400 Daltons.

It has surprisingly been found that such multi-aziridine compounds
5 have reduced genotoxicity compared to the very often used trimethylolpropane tris(2-methyl-1-aziridinepropionate). The multi-aziridine compounds show either only weakly positive induced genotoxicity or they do not show genotoxicity at all, i.e. they show a genotoxicity level comparable with the naturally occurring background. Accordingly, the multi-aziridine compounds with reduced genotoxicity compared to
10 trimethylolpropane tris(2-methyl-1-aziridinepropionate) have a more favourable hazardous profile than trimethylolpropane tris(2-methyl-1-aziridinepropionate) greatly reducing safety, health and environmental risks associated with their use, resulting in that the operational and administrative burden of handling of the multi-aziridine compounds with reduced genotoxicity can be reduced or even removed. The multi-
15 aziridine compound preferably comprises one or more connecting groups whereby each one of the connecting groups connects two of the structural units A and whereby the connecting groups and its preferences are as defined above.

In this embodiment, the amount of aziridinyl group functional molecules (also referred to as aziridine functional molecules), present in the coating
20 composition according to the invention, having a molecular weight lower than 250 Daltons, more preferably lower than 350 Daltons, even more preferably lower than 450 Daltons, even more preferably lower than 550 Daltons and even more preferably lower than 580 Daltons is preferably lower than 5 wt.%, more preferably lower than 4 wt.%, more preferably lower than 3 wt.%, more preferably lower than 2 wt.%, more
25 preferably lower than 1 wt.%, more preferably lower than 0.5 wt.%, more preferably lower than 0.1 wt.% and most preferably 0 wt.%, relative to the total weight of the coating composition, whereby the molecular weight is determined using LC-MS as described in the experimental part below. Such aziridine functional molecules may be obtained as side-products during preparation of the multi-aziridine compound as
30 defined herein.

The average number of aziridinyl groups per aziridinyl-containing molecule in the composition is preferably at least 1.8, more preferably at least 2, more preferably at least 2.2 and preferably less than 10, more preferably less than 6 and most preferably less than 4. Most preferably, the average number of aziridinyl groups
35 per aziridinyl-containing molecule in the composition is from 2.2 to 3.

Aqueous dispersion

The aqueous coating composition of the invention comprises at least two dispersed phases with different composition, wherein the first dispersed phase
5 comprises particles X which particles X comprise a multi-aziridine compound as defined herein, and the second dispersed phase comprises particles Y which particles Y comprise carboxylic acid functional polymer crosslinkable with the multi-aziridine
10 compound as defined herein, with the proviso that particles X neither comprise carboxylic acid functional polymer nor other compounds crosslinkable with the multi-aziridine compound as defined herein and particles Y neither comprise multi-aziridine
15 compound nor other compounds crosslinkable with the carboxylic acid functionality of the carboxylic acid functional polymer. The aqueous coating composition of the invention may further comprise particles comprising multi-aziridine compound and carboxylic acid functional polymer. Such particles can arise from coagulation of
20 particles X and particles Y. Preferably, the amount of particles comprising multi-aziridine compound and carboxylic acid functional polymer is less than 30 wt.%, preferably less than 20 wt.%, more preferably less than 10wt.%, even more preferably less than 5 wt.% on the total amount of the aqueous coating composition.

20 The pH of the aqueous coating composition is at least 8. For further prolonging the shelf-life of the aqueous dispersion of the invention, it is beneficial that the pH is at least 8.5, preferably at least 9, more preferably at least 9.5. The pH of the aqueous coating composition is at most 14, preferably at most 13, more preferably at most 12, even more preferably at most 11.5 and even more preferably at most 11,
25 since this allows to lower the amount of base present in the aqueous coating composition of the invention while the shelf life of the aqueous coating composition remains sufficiently long. Most preferably, the pH of the aqueous coating composition is in the range from 9.5 to 11.5.

The coating composition preferably comprises ammonia, a secondary
30 amine, a tertiary amine, LiOH, NaOH and/or KOH to adjust the pH to the desired value. Preferred amines are ammonia, secondary amines and/or tertiary amines. Examples of such secondary amines are, but not limited to, diisopropylamine, di-sec-butylamine and di-t-butylamine. More preferred amines are tertiary amines. Examples of such tertiary amines are, but not limited to, n-ethylmorpholine, n-methyl piperidine,

n,n-dimethyl butyl amine, dimethyl isopropyl amine, dimethyl n-propyl amine, dimethyl ethylamine, triethylamine, dimethyl benzyl amine, n,n-dimethyl ethanolamine, 2-(diethylamino)ethanol, n,n-dimethyl isopropanol amine, 1-dimethylamino-2-propanol, 3-dimethylamino-1-propanol, 2-(dimethylamino)ethanol, 2-[2-(dimethylamino)ethoxy] ethanol. Preferred tertiary amines are n-ethylmorpholine, n-methyl piperidine, n,n-dimethyl butyl amine, dimethyl isopropyl amine, dimethyl n-propyl amine, dimethyl ethylamine, triethylamine and/or dimethyl benzyl amine. Most preferred is triethylamine.

The amount of water in the aqueous coating composition is preferably at least 10 15 wt.%, more preferably at least 20 wt.%, more preferably at least 30 wt.%, even more preferably at least 40wt.%, on the total weight of the aqueous coating composition. The amount of water in the aqueous coating composition is preferably at most 90 wt.%, preferably at most 85 wt.%, more preferably at most 80 wt.%, even more preferably at most 70 wt.%, even more preferably at most 60 wt.%, on the total 15 weight of the aqueous coating composition.

The multi-aziridine compound as defined herein is present in the aqueous coating composition in an amount of preferably at least 0.5 wt.%, more preferably at least 1 wt.%, more preferably at least 1.5 wt.%, more preferably at least 2 wt.%, even more preferably at least 3 wt.%, even more preferably at least 4 wt.%, even more 20 preferably at least 5 wt.%, even more preferably at least 7 wt.%, on the total solids content of the aqueous coating composition. The multi-aziridine compound as defined herein is present in the aqueous coating composition in an amount of preferably at most 50 wt.%, preferably at most 30 wt.%, more preferably at most 20 wt.%, more preferably at most 15 wt.%, even more preferably at most 12 wt.%, on the total solids 25 content of the aqueous coating composition.

The solids content of the coating composition of the invention is preferably in the range of from 5 to 65 wt.%. The solids content of the coating composition of the invention is more preferably at least 10, even more preferably at least 20, even more preferably at least 25, even more preferably at least 35, and at most 55, even more 30 preferably at most 50 and even more preferably at most 45 wt.%.

Preferably at least 50 wt.%, more preferably at least 85 wt.%, more preferably at least 95 wt.%, even more preferably at least 99 wt.% of the multi-aziridine compound as defined herein is present in the crosslinker composition in dispersed form. Accordingly, the coating composition of the invention comprises

particles X comprising the multi-aziridine compound as defined herein. Said particles X preferably have a scatter intensity based average hydrodynamic diameter from 30 to 500 nanometer, more preferably from 50 to 350 nm, even more preferably from 110 to 275 nm. The scatter intensity based average hydrodynamic diameter of said particles may be controlled via a number of ways. For example, the scatter intensity based average hydrodynamic diameter of said particles may be controlled during the preparation of an aqueous dispersion of the invention by using different types of dispersants, and/or different amounts of dispersant(s), and/or by applying different shear stress, and/or by applying different temperature. For example, the scatter intensity based average hydrodynamic diameter of the particles is inversely dependent to the amount of the dispersant used in the preparation of an aqueous dispersion of the invention; for example, the scatter intensity based average hydrodynamic diameter of the particles decreases by increasing the amount of a dispersant. For example, the scatter intensity based average hydrodynamic diameter of the particles is inversely dependent to the shear stress applied during the preparation of an aqueous dispersion of the invention; for example, the scatter intensity based average hydrodynamic diameter of the particles decreases by increasing the shear stress. Exemplary dispersants include but are not limited to ATLAS™ G-5000, ATLAS™ G-5002L-LQ, Maxemul™ 7101 supplied by Croda.

The coating composition further comprises particles Y comprising carboxylic acid functional polymer crosslinkable with the multi-aziridine compound as defined herein. Said particles comprising carboxylic acid functional polymer preferably have a scatter intensity based average hydrodynamic diameter from 30 to 30000 nanometer, more preferably from 40 to 10000 nm, even more preferably from 40 to 3000 nanometer, even more preferably from 40 to 500 nm, even more preferably from 60 to 260 nm.

The carboxylic acid functional polymer is preferably selected from the group consisting of polyesters, polycarbonates, polyamides, vinyl polymers, polyacrylates, polymethacrylates, poly(acrylate-co-methacrylate)s, polyurethanes, poly(urethane-co-acrylate)s, poly(urethane-co-methacrylate)s, poly(urethane-co-acrylate-co-methacrylate), polyureas, and mixtures thereof. In an embodiment of the invention, preferred crosslinkable carboxylic acid functional polymers are selected from the group consisting of vinyl polymers, polyacrylates, polymethacrylates, poly(acrylate-co-methacrylate)s and mixtures thereof. Preferably by vinyl polymer is meant a polymer comprising reacted residues of styrene and acrylates and/or methacrylates. In another embodiment, the carboxylic acid functional polymer is

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selected from the group consisting of polyurethanes, poly(urethane-co-acrylate)s, poly(urethane-co-methacrylate)s, poly(urethane-co-acrylate-co-methacrylate), polyureas, and mixtures thereof.

The acid value of the carboxylic acid functional polymer is preferably
5 from 2 to 135 mg KOH/gram of the carboxylic acid functional polymer, more preferably from 3 to 70 mg KOH/g carboxylic acid functional polymer, even more preferably from 5 to 50 mg KOH/g carboxylic acid functional polymer and even more preferably from 10 to 25 mg KOH/g carboxylic acid functional polymer. As used
10 herein, the acid value of the carboxylic acid functional polymer(s) is calculated according to the formula $AV = ((\text{total molar amount of carboxylic acid components included in the carboxylic acid functional polymer(s) per gram of total amount of components included in the carboxylic acid functional polymer(s)}) * 56.1 * 1000)$ and is denoted as mg KOH/gram carboxylic acid functional polymer(s). The acid value of the carboxylic acid functional polymer(s) can thus be controlled by the molar amount of
15 carboxylic acid components that is used to prepare the carboxylic acid functional polymer(s). In case the acid value cannot be properly calculated, the acid value is determined by ASTM D1639-90(1996)e1.

The ratio of number-average molecular weight M_n of the carboxylic
20 acid functional polymer to acid value of the carboxylic acid functional polymer is preferably at least 150, more preferably at least 300, even more preferably at least 600, even more preferably at least 1000, even more preferably at least 5000 and most preferably at least 15000. As used herein, the number-average molecular weight M_n of the carboxylic acid functional polymer is determined by Size Exclusion
25 Chromatography with NMP-MEK.

The coating composition comprises at least one carboxylic acid functional polymer. The coating composition may comprise a blend of different carboxylic acid functional polymers. The carboxylic acid functional polymers contain carboxylic acid groups and/or carboxylate groups which are preferably free of a covalent bond that
30 blocks these groups to chemically react with the aziridine moiety present in the multi-aziridine compound. As used herein, the amount of carboxylic acid groups present in the carboxylic acid functional polymer is the summed amount of deprotonated and protonated carboxylic acid groups present in the polymer to be crosslinked, i.e. in the carboxylic acid functional polymer. Thus, the amount of carboxylic acid groups
35 present in the carboxylic acid functional polymer is the summed amount of

carboxylate groups and carboxylic acid groups present in the carboxylic acid functional polymer. The polymer to be crosslinked preferably comprises carboxylate groups which are at least partially neutralized with base. Preferably at least part of the base is a volatile base. Preferably, at least a part of the carboxylic acid groups present in the carboxylic acid functional polymer to be crosslinked are subjected to deprotonation to obtain carboxylate groups. The deprotonation is effected by neutralizing the carboxylic acid functional polymer with a base. Examples of suitable bases are ammonia, secondary amines, tertiary amines, LiOH, NaOH and/or KOH. Examples of secondary amines and tertiary amines are described above. Preferred bases are tertiary amines. Preferred tertiary amines are as described above. Most preferred is triethylamine.

The coating composition of the invention preferably comprises carboxylic acid functional polymer in an amount of at least 3 wt.%, preferably at least 5 wt.%, more preferably at least 10 wt.%, more preferably at least 20 wt.%, even more preferably at least 30 wt.%, even more preferably at least 40 wt.%, even more preferably at least 50 wt.%, on the total weight of the aqueous coating composition. The coating composition of the invention preferably comprises carboxylic acid functional polymer in an amount of at most 60 wt.%, preferably at most 55 wt.%, on the total weight of the aqueous coating composition.

Preferably, the amounts of aziridinyl groups and of carboxylic acid groups are chosen such that the stoichiometric amount (SA) of aziridinyl groups on carboxylic acid groups is from 0.1 to 2.0, more preferably from 0.2 to 1.5, even more preferably from 0.25 to 0.95, most preferably from 0.3 to 0.8.

The multi-aziridine compound as defined above is usually obtained in a composition in which, next to the multi-aziridine compound, remaining starting materials, side-products and/or solvent used in the preparation of the multi-aziridine compounds may be present. The composition may contain only one multi-aziridine compound as defined above but may also contain more than one multi-aziridine compound as defined above. Mixtures of multi-aziridine compounds are for example obtained when a mixture of polyisocyanates as starting material are used. The coating composition of the invention can be obtained by (i) dispersing the multi-aziridine compound into water and adjusting the pH of the aqueous dispersion to the desired value or by dispersing the multi-aziridine compound into a mixture of water

and at least one base which mixture has a pH such as to obtain an aqueous dispersion with the desired pH value, and (ii) mixing the aqueous dispersion obtained in step (i) with an aqueous dispersion of the carboxylic acid functional polymer. Dispersing of the multi-aziridine in water or into a mixture of water and at least one

5 base can be done using techniques well-known in the art. Solvents and/or high shear can be utilized in order to assist in the dispersion of the multi-aziridine compound. Alternatively, the multi-aziridine compound can be self-dispersing in which case it can directly be added to the carboxylic acid functional polymer to form separate particles. The multi-aziridine can become self-dispersing by incorporating ionic groups, polar

10 non-ionic groups such as polyalkylene oxides or any combination thereof.

The aqueous coating composition may further comprise organic solvent in an amount of at most 35 wt.%, preferably at most 30, for example at most 25, for example at most 20, for example at most 12, for example at most 10, for

15 example at most 8, for example at most 5, for example at most 4, for example at most 3, for example at most 2, for example at most 1, for example at most 0.5, for example at most 0.2, for example at most 0.1 wt% on the total weight of the aqueous coating composition. Organic solvent may optionally be added before, during and/or after synthesis of the multi-aziridine(s). Organic solvent can be utilized in order to assist in

20 dispersing the multi-aziridine compound in water. If desired, organic solvent can be removed afterwards from the crosslinker composition by reduced pressure and/or increased temperatures. Typical organic solvents are glycols, ethers, alcohols, cyclic carbonates, pyrrolidones, dimethylsulfoxide, n-formylmorpholine, dimethylformamide, amides and ketones. Preferred solvents are glycols (including glycol ethers), ethers,

25 alcohols, cyclic carbonates and ketones.

Preferably the dispersing of the multi-aziridine compound is done in the presence of a dispersant. Accordingly, the aqueous coating composition of the invention preferably comprises a dispersant. In the context of the present invention, a

30 dispersant is a substance that promotes the formation and colloidal stabilisation of a dispersion. In the present invention, said dispersant is preferably a species that is non-covalently attached to the multi-aziridine compound and/or said dispersant is a separate molecule component that is surface-active. Examples of species non-covalently attached to the multi-aziridine compound are urethane and/or urea

35 containing amphiphilic compounds such as HEUR thickeners.

More preferably, said dispersant is at least one separate molecule component that is surface-active. Preferred separate surface-active molecule components are:

- 5 (i) multi-aziridine compounds as defined above containing functional groups such as sulphonate, sulphate, phosphate and/or phosphonate functional groups, preferably sulphonate and/or phosphonate groups, more preferably sulphonate groups, and/or
- 10 (ii) a polymer preferably having a number average molecular weight as measured with MALDI-ToF-MS as described below of at least 2000 Daltons, more preferably at least 2500 Daltons, more preferably at least 3000 Daltons, more preferably at least 3500 Daltons, more preferably at least 4000 Daltons, and preferably at most 1000000 Daltons, more preferably at most 100000, at most 10000 Daltons.

More preferred separate surface-active molecule components are

15 polymers having a number average molecular weight as measured with MALDI-ToF-MS as described below of at least 2000 Daltons, more preferably at least 2500 Daltons, more preferably at least 3000 Daltons, more preferably at least 3500 Daltons, more preferably at least 4000 Daltons, and preferably at most 1000000 Daltons, more preferably at most 100000, even more preferably at most 10000

20 Daltons. Preferred polymers are polyethers, more preferably polyether copolymers, even more preferably polyether block copolymers, even more preferably poly(alkylene oxide) block copolymers, even more preferably poly(ethylene oxide)- co-poly(propylene oxide) block copolymers. Non-limited examples of preferred separate surface-active molecule dispersants are Atlas™ G-5000 obtainable from Croda,

25 Maxemul™ 7101 from Croda and/or Pluronic® P84 from BASF. The amount of separate surface-active molecule component is generally in the range of from 0.1 to 20 wt.%, preferably at least 0.5, more preferably at least 1, even more preferably at least 2, even more preferably at least 3 wt.%, based on the total weight of the aqueous coating composition.

30 Multi-aziridine compounds as defined under (i) containing functional groups such as sulphonate, sulphate, phosphate and/or phosphonate functional groups, preferably containing sulphonate functional groups, are preferably obtained by reacting part of the isocyanate groups of the polyisocyanates used to prepare the multi-aziridine compound with a hydroxy or amine functional ionic building block

35 (preferably neutralized with an inorganic base). Examples of hydroxy or amine

functional ionic building blocks include 2-(cyclohexylamino)ethanesulfonic acid, 3-cyclohexyl-amino)propanesulfonic acid, methyltaurine, taurine, Tegomer® DS-3404. Preferably sulfonic acid salts are used as hydroxy or amine functional ionic building block.

- 5 Crosslinking efficiency of a crosslinker can be assessed by assessing the chemical resistance defined and determined as described below.

Storage stability of an aqueous coating composition according to the invention can be assessed by storing the aqueous coating composition in particular at increased temperature, e.g. 50 °C, and assessing the change of
10 viscosity, defined and determined as described below, of the stored aqueous coating composition and/or assessing the change of the chemical resistance, defined and determined as described below, in particular the ethanol resistance, of the stored coating composition.

15 The aqueous coating composition of the present invention preferably has a storage stability of at least 1 week, preferably at least 2 weeks, more preferably at least 3 weeks and even more preferably at least 4 weeks at 50°C. Storage stable for at least x week(s) at 50°C means that after the aqueous coating composition has been stored for x week at 50°C (i) the end viscosity of the aqueous
20 coating composition is at most 50 times higher than the starting viscosity, preferably at most 45 times higher than the starting viscosity, more preferably at most 40 times higher than the starting viscosity, more preferably at most 35 times higher than the starting viscosity, more preferably at most 30 times higher than the starting viscosity, more preferably at most 25 times higher than the starting viscosity, more preferably
25 at most 20 times higher than the starting viscosity, more preferably at most 15 times higher than the starting viscosity, more preferably at most 10 times higher than the starting viscosity and most preferably at most 5 times higher than the starting viscosity and/or (ii) the chemical resistance, defined and determined as described below, of the aqueous coating composition decreases with at most 3 points,
30 preferably with at most 2 points, and even more preferably with at most 1 point. Preferably, storage stable for at least x week(s) at 50°C means that after the dispersion has been stored for x week at 50°C (i) the end viscosity of the aqueous dispersion is at most 50 times higher than the starting viscosity, preferably at most 45 times higher than the starting viscosity, more preferably at most 40 times higher than

the starting viscosity, more preferably at most 35 times higher than the starting viscosity, more preferably at most 30 times higher than the starting viscosity, more preferably at most 25 times higher than the starting viscosity, more preferably at most 20 times higher than the starting viscosity, more preferably at most 15 times higher than the starting viscosity, more preferably at most 10 times higher than the starting viscosity and most preferably at most 5 times higher than the starting viscosity and (ii) the chemical resistance, defined and determined as described below, of the aqueous dispersion decreases with at most 3 points, preferably with at most 2 points, and even more preferably with at most 1 point. By 'starting viscosity' of an aqueous coating composition is meant the viscosity (assessed as described below) of the aqueous coating composition determined upon its preparation and just before the aqueous coating composition is stored at 50 °C. By 'end viscosity' of an aqueous coating composition is meant the viscosity (assessed as described below) of the aqueous coating composition determined after the aqueous coating composition was stored for x weeks at 50 °C.

The present invention further relates to a process for preparing the coating composition according to the invention, wherein the process comprises (i) dispersing the multi-aziridine compound as defined herein above into water to obtain an aqueous dispersion and adjusting the pH of the aqueous dispersion to a desired value or the process comprises dispersing the multi-aziridine compound as defined in herein above into a mixture of water and at least one base which mixture has a pH such as to obtain an aqueous dispersion with a desired pH value, and (ii) mixing the aqueous dispersion obtained in step (i) with an aqueous dispersion of the carboxylic acid functional polymer. Preferably, the process comprises mixing basic aqueous medium into the multi-aziridine compound as defined herein above, whereby the pH of the basic aqueous medium is chosen such as to obtain an aqueous dispersion with the desired pH value.

In a preferred embodiment of the invention, the dispersant is a separate surface-active polymer having a number average molecular weight of at least 2000 Daltons (ii). In this preferred embodiment, the process for preparing the coating composition of the invention preferably comprises

A) optionally but preferably mixing the multi-aziridine compound as defined herein above in an organic solvent,

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B) mixing the multi-aziridine compound as defined herein above or the solution obtained in step A) with a dispersant to obtain a composition comprising the multi-aziridine compound and dispersant,

5 C) mixing water and base or mixing basic aqueous medium into said composition comprising the multi-aziridine compound and dispersant, to obtain a dispersion

D) optionally, but preferably, evaporating organic solvent from said dispersion to obtain a further dispersion, and optionally mixing additional water or basic aqueous medium into said further dispersion, to obtain an aqueous dispersion
10 of the multi-aziridine compound, and

E) mixing the aqueous dispersion of the multi-aziridine compound obtained in step D) with an aqueous dispersion of the carboxylic acid functional polymer, to obtain the coating composition of the invention.

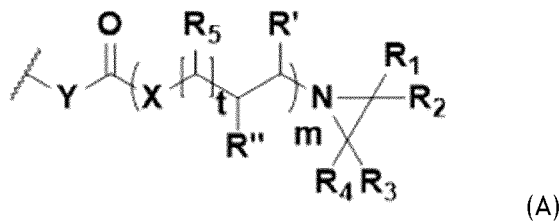
Step C) is preferably effected using a high-shear dispersion equipment.

15 The present invention further relates to a substrate having a coating obtained by (i) applying a coating composition as described above to a substrate and (ii) drying the coating composition by evaporation of volatiles. The drying of the coating composition is preferably effected at a temperature lower than 160 °C, preferably at a temperature lower than 90 °C, more preferably at a temperature lower
20 than 50 °C and most preferably at ambient temperature. The coating composition according to the invention can be applied to any kind of substrate, such as for example wood, leather, concrete, textile, plastic, vinyl floors, glass, metal, ceramics, paper, wood plastic composite, glass fiber reinforced materials. The thickness of the dry coating on the substrate is preferably from 1 to 200 micron, more preferably from
25 5 to 150 micron and most preferably from 15 to 90 microns. In case the coating composition is an ink composition, the thickness of the dry ink is preferably from 0.005 to 35 micron, more preferably from 0.05 to 25 micron and most preferably from
30 4 to 15 microns.

The invention is further defined by the set of exemplary
embodiments as listed hereafter. Any one of the embodiments, aspects and preferred
features or ranges as disclosed in this application may be combined in any
combination, unless otherwise stated herein or if technically clearly not feasible to a
35 skilled person.

[1] An aqueous coating composition comprising a multi-aziridine compound and a carboxylic acid functional polymer, wherein

- 5 (i) the composition is an aqueous dispersion having a pH ranging from 8 to 14,
- (ii) the aqueous dispersion comprises particles X which particles X comprise multi-aziridine compound and particles Y which particles Y comprise carboxylic acid functional polymer, and
- 10 (iii) said multi-aziridine compound has:
- a) from 2 to 6 of the following structural units A:



whereby

R_1 is H,

15 R_2 and R_4 are independently chosen from H or an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,

R_3 is an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,

m is an integer from 1 to 6,

R' and R'' are according to (1) or (2):

20 (1) $R' = H$ or an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, and

25 $R'' = H$, an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, a cycloaliphatic hydrocarbon group containing from 5 to 12 carbon atoms, an aromatic hydrocarbon group containing from 6 to 12 carbon atoms, $CH_2-O-(C=O)-R'''$, CH_2-O-R''' , or $CH_2-(OCR''''HCR''''H)_n-OR''''$, whereby R''' is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms and R'''' is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms or an aromatic hydrocarbon group containing from 6 to 12 carbon atoms, n being from 1 to 35, R'''' independently being H or an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms and R''''''

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being an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,

(2) R' and R'' form together a saturated cycloaliphatic hydrocarbon group containing from 5 to 8 carbon atoms,

5 t is an integer from 0 to 3,

R₅ is H or CH₃,

X and Y are according to (I), (II) or (III):

(I) X and Y are both N-R₆;

(II) X is O and Y is N-R₆;

10 (III) X is N-R₆ and Y is O,

whereby R₆ is H or a linear or branched hydrocarbon group containing from 1 to 4 carbon atoms;

b) one or more linking chains wherein each one of these linking chains links two of the structural units A; and

15 c) a molecular weight in the range from 500 to 10000 Daltons.

[2] The aqueous coating composition of embodiment 1, wherein R₂ is H, R₃ is C₂H₅ and R₄ is H.

[3] The aqueous coating composition of embodiment 1, wherein R₂ is H, R₃ is CH₃ and R₄ is H.

20 [4] The aqueous coating composition of embodiment 1, wherein R₂ is H, R₃ is CH₃ and R₄ is CH₃.

[5] The aqueous coating composition of any of embodiments [1] to [4], wherein m is 1.

[6] The aqueous coating composition of any of embodiments [1] to [5], wherein t is 0 or 1.

[7] The aqueous coating composition of any of embodiments [1] to [6], wherein R₆ is H.

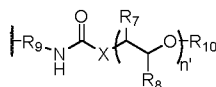
[8] The aqueous coating composition of any of embodiments [1] to [4], wherein X is O, Y is NH, m is 1 and t is 0.

30 [9] The aqueous coating composition of any of embodiments [1] to [8], wherein the linking chains consist of from 4 to 300 atoms, more preferably from 5 to 250 and most preferably from 6 to 100 atoms and the linking chains are a collection of atoms covalently connected which collection of atoms consists of i) carbon atoms, ii) carbon and nitrogen atoms, or iii) carbon, oxygen and
35 nitrogen atoms.

- [10] The aqueous coating composition of any of embodiments [1] to [9], wherein the multi-aziridine compound contains 2 or 3 structural units A.
- [11] The aqueous coating composition of any of embodiments [1] to [10], wherein R' and R'' are according to (1) or (2):
- 5 (1) R' = H or an alkyl group containing from 1 to 2 carbon atoms;
R'' = H, an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms, CH₂-O-(C=O)-R''', CH₂-O-R''', or CH₂-(OCR''''HCR''''H)_n-OR''''', whereby R''' is an alkyl group containing from 1 to 14 carbon atoms and R'''' is an alkyl group containing from 1 to 14 carbon atoms, n being from 1
- 10 to 35, R'''' independently being H or a methyl group and R'''''' being an alkyl group containing from 1 to 4 carbon atoms;
- (2) R' and R'' form together a saturated cycloaliphatic hydrocarbon group containing from 5 to 8 carbon atoms.
- [12] The aqueous coating composition of any of embodiments [1] to [10], wherein
- 15 R' is H and R'' = an alkyl group containing from 1 to 4 carbon atoms, CH₂-O-(C=O)-R''', CH₂-O-R''', whereby R''' is an alkyl group containing from 3 to 12 carbon atoms and R'''' is an alkyl group containing from 1 to 14 carbon atoms.
- [13] The aqueous coating composition of any of embodiments [1] to [12], wherein
- 20 the multi-aziridine compound comprises one or more connecting groups wherein each one of these connecting groups connects two of the structural units A, whereby the connecting groups consist of at least one functionality selected from the group consisting of aliphatic hydrocarbon functionality (preferably containing from 1 to 8 carbon atoms), cycloaliphatic hydrocarbon functionality (preferably containing from 4 to 10 carbon atoms), aromatic
- 25 hydrocarbon functionality (preferably containing from 6 to 12 carbon atoms), isocyanurate functionality, iminoxadiazindione functionality, ether functionality, ester functionality, amide functionality, carbonate functionality, urethane functionality, urea functionality, biuret functionality, allophanate functionality, uretdione functionality and any combination thereof.
- 30 [14] The aqueous coating composition of embodiment [13], wherein the connecting groups consist of at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality and optionally at least one aromatic hydrocarbon functionality and optionally an isocyanurate functionality or an iminoxadiazindione functionality.

[15] The aqueous coating composition of embodiment [13], wherein the connecting groups consist of at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality and an isocyanurate functionality or an iminooxadiazindione functionality.

5 [16] The aqueous coating composition of any of embodiments [1] to [12], wherein the multi-aziridine compound comprises one or more connecting groups wherein each one of these connecting groups connects two of the structural units A, wherein the connecting groups consist of (i) at least two aliphatic hydrocarbon functionality and (ii) an isocyanurate functionality or an
 10 iminooxadiazindione functionality, and wherein a pendant group is present on a connecting group, whereby the pendant group has the following structural formula :



15 n' is the number of repeat units and is an integer from 1 to 50, preferably from 2 to 30, more preferably from 5 to 20.

X is O or NH, preferably X is O,

R_7 and R_8 are independently H or CH_3 in each repeating unit,

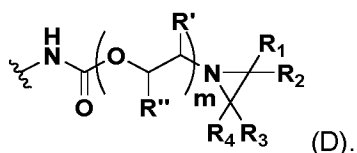
20 R_9 is an aliphatic hydrocarbon group, preferably containing from 1 to 8 carbon atoms, and

R_{10} preferably is an aliphatic hydrocarbon group containing from 1 to 20 carbon atoms (preferably CH_3), a cycloaliphatic hydrocarbon group containing from 5 to 20 carbon atoms or an aromatic hydrocarbon group containing from 6 to 20 carbon atoms.

25 [17] An aqueous coating composition, wherein the composition is an aqueous coating composition having a pH ranging from 8 to 14 and comprising a multi-aziridine compound in dispersed form and comprising carboxylic acid functional polymer in dispersed form, wherein said multi-aziridine compound has from 2 to 6 of the structural units A as defined in embodiment [1], whereby
 30 R_1 , R_2 , R_3 , R_4 , R' , R'' , m , t , R_5 , X and Y are as defined in any of embodiment [1] to [12], wherein the multi-aziridine compound having a molecular weight from 500 Daltons to 10000 Daltons and wherein the multi-aziridine compound

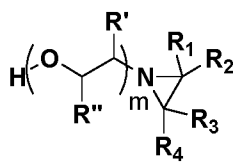
further comprises one or more connecting groups wherein each one of these connecting groups connects two of the structural units A, in which the connecting groups consist of at least one functionality selected from the group consisting of aliphatic hydrocarbon functionality (preferably containing from 1 to 8 carbon atoms), cycloaliphatic hydrocarbon functionality (preferably containing from 4 to 10 carbon atoms), aromatic hydrocarbon functionality (preferably containing from 6 to 12 carbon atoms), isocyanurate functionality, iminooxadiazindione functionality, ether functionality, ester functionality, amide functionality, carbonate functionality, urethane functionality, urea functionality, biuret functionality, allophanate functionality, uretdione functionality and any combination thereof.

[18] The aqueous coating composition of any of embodiments [1] to [17], wherein structural units A are according to the following structural formula D:



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[19]. The aqueous coating composition of any of embodiments [1] to [18], wherein the multi-aziridine compound is obtained by reacting at least a polyisocyanate and a compound B with the following structural formula:



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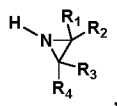
whereby the molar ratio of compound B to polyisocyanate is from 2 to 6, more preferably from 2 to 4 and most preferably from 2 to 3, and whereby m, R', R'', R₁, R₂, R₃ and R₄ are defined as in the preceding embodiments.

[20] The aqueous coating composition of embodiment [19], wherein the polyisocyanate is a polyisocyanate with aliphatic reactivity.

25

[21] The aqueous coating composition of embodiment [19] or [20], wherein compound B is obtained by reacting at least a non-OH functional monoepoxide compound with an aziridine with the following structural formula:

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whereby R₁, R₂, R₃ and R₄ are defined as in the preceding embodiments.

- [22] The aqueous coating composition of embodiment [21], wherein the non-OH functional monoepoxide compound is selected from the group consisting of ethylene oxide, propylene oxide, 2-ethyl oxirane, n-butylglycidylether, 2-ethylhexylglycidylether, glycidyl neodecanoate and any mixture thereof.
- [23] The aqueous coating composition of any of embodiments [19] to [22], wherein the multi-aziridine compound is the reaction product of a least compound (B), a polyisocyanate and alkoxy poly(propyleneglycol) and/or poly(propyleneglycol).
- [24] The aqueous coating composition of any of embodiments [1] to [23], wherein the multi-aziridine compound has a molecular weight of from 600 to 5000 Daltons, more preferably the multi-aziridine compound has a molecular weight of at least 800 Daltons, even more preferably at least 840 Daltons, even more preferably at least 1000 Daltons and preferably at most 3800 Daltons, more preferably at most 3600 Daltons, more preferably at most 3000 Daltons, more preferably at most 1600 Daltons, even more preferably at most 1400 Daltons.
- [25] The aqueous coating composition of any of embodiments [1] to [24], wherein the aqueous coating composition comprises aziridine functional molecules having a molecular weight lower than 250 Daltons, more preferably lower than 350 Daltons, even more preferably lower than 450 Daltons, even more preferably lower than 550 Daltons and even more preferably lower than 580 Daltons in an amount lower than 5 wt.%, preferably lower than 4 wt.%, more preferably lower than 3 wt.%, more preferably lower than 2 wt.%, more preferably lower than 1 wt.%, more preferably lower than 0.5 wt.%, more preferably lower than 0.1 wt.% and most preferably 0 wt.% on the total weight of the aqueous coating composition, whereby the molecular weight is determined using LC-MS as described in the description.
- [26] The aqueous coating composition of any of embodiments [1] to [25], wherein the pH of the aqueous coating composition is at least 8.5, more preferably at least 9, more preferably at least 9.5.

- [27] The aqueous coating composition of any of embodiments [1] to [26], wherein the pH of the aqueous coating composition is at most 14, more preferably at most 13, even more preferably at most 12, even more preferably at most 11.5.
- [28] The aqueous coating composition of any of embodiments [1] to [27], wherein
5 the pH of the aqueous coating composition is in the range from 9.5 to 11.5.
- [29] The aqueous coating composition of any of embodiments [1] to [28], wherein the aqueous coating composition comprises ammonia, a secondary amine(s), a tertiary amine(s), LiOH, NaOH and/or KOH to adjust the pH to the desired value, preferably the aqueous coating composition comprises a tertiary amine
10 selected from
n-ethylmorpholine, n-methyl piperidine, n,n-dimethyl butyl amine, dimethyl isopropyl amine, dimethyl n-propyl amine, dimethyl ethylamine, triethylamine and/or dimethyl benzyl amine, most preferably comprises triethylamine to adjust the pH to the desired value.
- [30] The aqueous coating composition of any of embodiments [1] to [29], wherein
15 the amount of water in the aqueous coating composition is at least 15 wt.%, preferably at least 20 wt.%, more preferably at least 30 wt.%, even more preferably at least 40wt.%, on the total weight of the aqueous coating composition.
- [31] The aqueous coating composition of any of embodiments [1] to [30], wherein
20 the amount of water in the aqueous coating composition is at most 95 wt.%, preferably at most 90 wt.%, more preferably at most 85 wt.%, more preferably at most 80 wt.%, even more preferably at most 70 wt.%, even more preferably at most 60 wt.%, on the total weight of the aqueous coating composition.
- [32] The aqueous coating composition of any of embodiments [1] to [31], wherein
25 the amount of said multi-aziridine compound in the aqueous coating composition is at least 0.5 wt.%, preferably at least 1 wt.%, more preferably at least 1.5 wt.%, more preferably at least 2 wt.%, even more preferably at least 3 wt.%, even more preferably at least 4 wt.%, even more preferably at least 5
30 wt.%, on the total solids content of the aqueous coating composition.
- [33] The aqueous coating composition of any of embodiments [1] to [32], wherein the amount of said multi-aziridine compound in the aqueous coating composition is at most 50 wt.%, preferably at most 30 wt.%, more preferably

at most 20 wt.%, even more preferably at most 15 wt.% and even more preferably at most 12 wt.%, on the total solids content of the aqueous coating composition.

- 5 [34] The aqueous coating composition of any of embodiments [1] to [33], wherein the aqueous coating composition comprises carboxylic acid functional polymer in an amount of at least 3 wt.%, preferably at least 5 wt.%, more preferably at least 10 wt.%, more preferably at least 20 wt.%, even more preferably at least 30 wt.%, even more preferably at least 40 wt.%, even more preferably at least 50 wt.%, on the total weight of the aqueous coating composition.
- 10 [35] The aqueous coating composition of any of embodiments [1] to [34], wherein the aqueous coating composition comprises carboxylic acid functional polymer in an amount of at most 60 wt.%, preferably at most 55 wt.%, on the total weight of the aqueous coating composition.
- 15 [36] The aqueous coating composition of any of embodiments [1] to [35], wherein the amounts of aziridinyl groups and of carboxylic acid groups are chosen such that the stoichiometric amount (SA) of aziridinyl groups on carboxylic acid groups is from 0.1 to 2.0, more preferably from 0.2 to 1.5, even more preferably from 0.25 to 0.95, most preferably from 0.3 to 0.8.
- 20 [37] The aqueous coating composition of any of embodiments [1] to [36], wherein the aqueous coating composition further comprises an organic solvent in an amount of at most 35 wt.%, preferably at most 30, for example at most 25, for example at most 20, for example at most 12, for example at most 10, for example at most 8, for example at most 5, for example at most 4, for example at most 3, for example at most 2, for example at most 1, for example at most 0.5, for example at most 0.2, for example at most 0.1 wt% on the total weight of the aqueous coating composition.
- 25 [38] The aqueous coating composition of any of embodiments [1] to [37], wherein the solids content of the aqueous coating composition is at least 5, preferably at least 10, even more preferably at least 20, even more preferably at least 25, even more preferably at least 35 and at most 55, more preferably at most 50 and even more preferably at most 45 wt.%.
- 30 [39] The aqueous coating composition of any of embodiments [1] to [38], wherein the particles X have a scatter intensity based average hydrodynamic diameter from 30 to 500 nanometer, preferably from 30 to 350 nm, more preferably from 110 to 275 nm.
- 35

- [40] The aqueous coating composition of any of embodiments [1] to [39], wherein the particles Y have a scatter intensity based average hydrodynamic diameter from 30 to 30000 nanometer, more preferably from 40 to 10000 nm, even more preferably from 40 to 3000 nanometer, even more preferably from 40 to 500 nm, even more preferably from 60 to 260 nm.
- [41] The aqueous coating composition of any of embodiments [1] to [40], wherein the carboxylic acid functional polymer is selected from the group consisting of polyesters, polycarbonates, polyamides, vinyl polymers, polyacrylates, polymethacrylates, poly(acrylate-co-methacrylate)s, polyurethanes, poly(urethane-co-acrylate)s, poly(urethane-co-methacrylate)s, poly(urethane-co-acrylate-co-methacrylate), polyureas, and mixtures thereof.
- [42] The aqueous coating composition of any of embodiments [1] to [40], wherein the carboxylic acid functional polymer is selected from the group consisting of vinyl polymers, polyacrylates, polymethacrylates, poly(acrylate-co-methacrylate)s and mixtures thereof.
- [43] The aqueous coating composition of any of embodiments [1] to [40], wherein the carboxylic acid functional polymer is selected from the group consisting of polyurethanes, poly(urethane-co-acrylate)s, poly(urethane-co-methacrylate)s, poly(urethane-co-acrylate-co-methacrylate), polyureas, and mixtures thereof.
- [44] The aqueous coating composition of any of embodiments [1] to [43], wherein the carboxylic acid functional polymer has an acid value of from 2 to 135 mg KOH/gram of the carboxylic acid functional polymer, more preferably from 3 to 70 mg KOH/g carboxylic acid functional polymer, even more preferably from 5 to 50 mg KOH/g carboxylic acid functional polymer and even more preferably from 10 to 25 mg KOH/g carboxylic acid functional polymer
- [45] The aqueous coating composition of any of embodiments [1] to [44], wherein the carboxylic acid functional polymer comprises carboxylate groups which are at least partially neutralized with a volatile tertiary amine.
- [46] The aqueous coating composition of any of embodiments [1] to [45], wherein the carboxylic acid functional polymer has a number average molecular weight M_n to acid value ratio of at least 150, more preferably at least 300, even more preferably at least 600, even more preferably at least 1000, even more preferably at least 5000 and most preferably at least 15000
- [47] The aqueous coating composition of any of embodiments [1] to [46], wherein the aqueous coating composition comprises a dispersant.

- [48] The aqueous coating composition of any of embodiments [1] to [47], wherein the aqueous coating composition comprises a separate surface-active molecule component as dispersant in an amount ranging from 0.1 to 20 wt.%, preferably at least 0.5, more preferably at least 1, even more preferably at least 2, even more preferably at least 3 wt.%, on the total weight of the aqueous coating composition.
- [49] The aqueous coating composition of embodiment [48], wherein the dispersant is a polymer having a number average molecular weight of at least 2000 Daltons, more preferably at least 2500 Daltons, more preferably at least 3000 Daltons, more preferably at least 3500 Daltons, more preferably at least 4000 Daltons, and preferably at most 1000000 Daltons, more preferably at most 100000, at most 10000 Daltons.
- [50] The aqueous coating composition of any of embodiments [47] to [49], wherein the dispersant is a polyether, more preferably a polyether copolymer, even more preferably a polyether block copolymer, even more preferably a poly(alkylene oxide) block copolymer, even more preferably a poly(ethylene oxide)-*co*-poly(propylene oxide) block copolymer.
- [51] The aqueous coating composition of any of embodiments [1] to [50], wherein the aqueous coating composition is self-crosslinkable.
- [52] The aqueous coating composition of any of embodiments [1] to [51], wherein the aqueous coating composition has a storage stability of at least 1 week, preferably of at least 2 weeks, more preferably of at least 3 weeks and even more preferably of at least 4 weeks at 50°C.
- [54] The aqueous coating composition of any of embodiments [1] to [53], wherein the particles X neither comprise carboxylic acid functional polymer nor other compounds crosslinkable with said multi-aziridine compound and particles Y does not comprise said multi-aziridine compound, preferably particles Y neither comprise said multi-aziridine compound nor other crosslinking compounds able to crosslink the carboxylic acid functionality of the carboxylic acid functional polymer, more preferably particles Y neither comprise said multi-aziridine compound nor other crosslinking compounds.
- [53] A process for preparing the aqueous coating composition of any of embodiments [1] to [52], wherein the process comprises dispersing the multi-aziridine compound as defined in any of the preceding embodiments into water to obtain an aqueous dispersion and adjusting the pH of the aqueous

dispersion to the desired value or wherein the process comprises dispersing the multi-aziridine compound as defined in any of the preceding embodiments into a mixture of water and at least one base which mixture has a pH such as to obtain an aqueous dispersion with the desired pH value.

5 [54] The process of embodiment [53], wherein the process comprises mixing basic aqueous medium into the multi-aziridine compound as defined in any of the preceding embodiments, whereby the pH of the basic aqueous medium is chosen such as to obtain an aqueous dispersion with the desired pH value, and (ii) mixing the aqueous dispersion obtained in step (i) with an aqueous
10 dispersion of the carboxylic acid functional polymer.

[55] The process of embodiment [54], wherein the process comprises

A) optionally but preferably mixing the multi-aziridine compound as defined in any of the preceding embodiments in an organic solvent,

B) mixing the multi-aziridine compound as defined in any of the
15 preceding embodiments or the solution obtained in step A) with a dispersant to obtain a composition comprising the multi-aziridine compound and dispersant,

C) mixing water and base or mixing basic aqueous medium into said composition comprising the multi-aziridine compound and
20 dispersant, to obtain a dispersion

D) optionally, but preferably, evaporating organic solvent from said dispersion to obtain a further dispersion, and optionally mixing additional water or basic aqueous medium into said further dispersion, to obtain an aqueous dispersion of the multi-aziridine compound, and

25 E) mixing the aqueous dispersion of the multi-aziridine compound obtained in step D) with an aqueous dispersion of the carboxylic acid functional polymer, to obtain the coating composition of any of embodiments [1] to [52].

[56] A substrate having a coating obtained by (i) applying an aqueous coating
30 composition of any of embodiments [1] to [52] to a substrate and (ii) drying the aqueous coating composition by evaporation of volatiles.

The present invention is now illustrated by reference to the following examples. Unless otherwise specified, all parts, percentages and ratios are on a
35 weight basis.

Particle size measurement

The scatter intensity based average hydrodynamic diameter of the particles was determined using a method derived from the ISO 22412:2017 standard with a Malvern Zetasizer Nano S90 DLS instrument that was operated under the following settings: as
5 material, a polystyrene latex was defined with a RI of 1.590 and an absorption of 0.10 with a continuous medium of demineralized water with a viscosity of 0.8812 cP and a RI of 1.332 at 25°C. Measurements were performed in DTS0012 disposable cuvettes, obtained from Malvern Instruments (Malvern, Worcestershire, United Kingdom).
10 Measurements were performed under a 173° backscatter angle as an average of 3 measurements after 120 seconds equilibration, consisting of 10-15 subruns – optimized by the machine itself. The focus point of the laser was at a fixed position of 4,65 cm and data was analyzed using a general-purpose data fitting process. Samples were prepared by diluting 0.05 g (1 droplet) sample dispersion in approximately 5 mL of
15 demineralized water. If the sample still looked hazy it was further diluted with distilled water until it becomes almost clear. This method is suitable for determining particle sizes from 2nm to 3µm.

pH measurement

The pH of a sample is determined based on the ISO 976:2013 standard. Samples are
20 measured at 23°C using a Metrohm 691 pH-meter equipped with combined glass electrode and PT-1000 temperature sensor. The pH-meter is calibrated using buffer solutions of pH 7.00 and 9.21 prior to use.

NCO determination

25 The NCO content of a sample is determined based on the ASTM D2572-19 standard. In the procedure, the sample is reacted with excess n-dibutylamine. The excess of n-dibutylamine is subsequently back-titrated with standard 1N hydrochloric acid (HCl). The difference in titration volume between the sample and a blank is the measure of the isocyanate content on solids, according to the following formula: $\%NCO_{\text{solids}} = [(V_b - V_m) * N * 4.2] / (A * s / 100)$, where $\%NCO_{\text{solids}}$ is the isocyanate content on solids,
30 V_b is the volume of HCl used in the blank, V_m is the volume of HCl used in the sample, N is the normality of the HCl solution, A is the sample weight in grams and s is the solids content of the sample in %. Measurements are performed in duplicate

using a potentiometric endpoint on a Metrohm 702SM Titrino titrator (accepting the measurement if the difference between duplicates is $< 0.1\%_{\text{NCO}}$).

AV determination

- 5 The acid value on solid material (AV) of a sample is determined based on the ASTM D1639-90(1996)e1 standard. In the procedure, the sample, dissolved in a good solvent, is titrated with alcoholic potassium hydroxide solution of a known concentration (KOH). The difference in titration volume between the sample and a blank is the measure of the acid value on solids, according to the following formula:
- 10 $AV = [(V_{\text{blank}} - V_{\text{sample}}) * N_{\text{KOH}} * 56.1] / (W * S / 100)$, where AV is acid number on solids in mg KOH/g solid material, V_{blank} is the volume of KOH solution used in the blank, V_{sample} is the volume of KOH solution used in the sample, N_{KOH} is the normality of the KOH solution, W is the sample weight in grams and S is the solids content of the sample in %. Measurements are performed in duplicate using a
- 15 potentiometric endpoint on a Metrohm 702SM Titrino titrator (accepting the measurement if the difference between duplicates is < 0.1 mg KOH/g solid material).

Chemical resistance

Chemical resistance testing based on DIN 68861-1:2011-01 standard.

- 20 Unless indicated otherwise the chemical resistance is tested as follows:
Coating compositions are treated as described in the examples, and then cast at 100 μm wet layer thickness using a wire bar applicator. After casting, films were dried for 1 hour at 25°C, then annealed at 50°C for 16 hours. Subsequently, a piece of cotton wool was soaked in 1:1 Ethanol : demineralized water (by weight) and placed on the film for
- 25 60 minutes (unless indicated otherwise). After removal of the cotton wool and overnight recovery, the spots were scored according to the following ranks:
- 1 Complete coating degradation
 - 2 Structural damage to the coating
 - 3 Severe marking on coating, visible from multiple directions
 - 30 4 Slight marking on coating, visible from specific angles
 - 5 No observed marking or gloss change

Viscosity measurements:

- The apparent viscosity is determined according to ISO 2555:2018. The measurement
- 35 is performed at 23°C on a Brookfield DVE-LV viscometer (single-cylinder geometry) at

60 rpm. The spindle is selected from S62, S63 or S64, using the lowest numbered spindle (*i.e.* the largest spindle) that yields a reading between 10% and 100% torque.

Size Exclusion Chromatography with NMP-MEK

- 5 The molecular weight distribution is measured with an Alliance Separation Module (Waters e2695), including a pump, autoinjector, degasser, and column oven. The eluent is n-Methyl pyrrolidone (NMP) 80% / methylethylketone 20% (MEK) with the addition of 0.01 M lithium bromide. The injection volume was 150 μ l. The flow was established at 1.0 ml/min. Three PL Mixed B (Polymer Laboratories) with a guard
- 10 column (5 μ m PL) were applied at a temperature of 70°C. The detection was performed with a differential refractive index detector (Waters 2414) at 50°C. The samples are dissolved in the eluent using a concentration of 5 mg polymer per mL solvent. The solubility is judged with a laser pen after 24 hours stabilization at room temperature; if any scattering is visible the samples are filtered first. The calculation
- 15 was performed with eight polystyrene standards (polymer standard services), ranging from 160 to 1,737,000 Dalton. The calculation was performed with Empower software (Waters) with a third order calibration curve. The obtained molar masses are polystyrene equivalent molar masses (Dalton).

T_g measurement by DSC

- 20 The glass transition temperature (T_g) of a polymer is measured by Differential Scanning Calorimetry (DSC) at a heating rate of 10°C/min in N₂ atmosphere at a flow rate of 50 mL/minute, on a TA Instruments Discovery DSC 250 apparatus according to the following method: a sample of 5 \pm 0,5 mg was weighed and placed in the DSC cell at a temperature between 20 and 25 °C. The sample was cooled down to -120 °C
- 25 and equilibrated at that temperature; upon equilibration the sample was heated up from -120 °C up to 160 °C at a heating rate of 5 °C/minute; the sample was kept at that temperature for 2 minutes and it was subsequently cooled down to -120 °C at a cooling rate of 20 °C/min; once the sample reached -120 °C the temperature was maintained for 5 minutes; subsequently, the sample was heated up from -120 °C up
- 30 to 220 °C at a heating rate of 5 °C/minute (thermograph A). The T_g was measured from this last thermograph (thermograph A) as the half width of the step in the DSC signal (DSC thermograph, Heat Flow vs. Temperature) observed for a T_g. The processing of the DSC signal and the determination of the T_g was carried out using TRIOS software package version 5.0 provided by TA instruments.

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Low molecular weight fraction by LC-MS

LC system: Agilent 1290 Infinity II; Detector #1: Agilent 1290 Infinity II PDA; Detector #2: Agilent iFunnel 6550 Q-TOF-MS.

LC-MS analysis for the low molecular weight fraction was performed using the following procedure. A solution of ~100 mg/kg of material was prepared gravimetrically in methanol and stirred. 0.5 µl of this solution was injected into a UPLC equipped with ESI-TOF-MS detection. The column used was a 100x2.1mm, 1.8µm, Waters HSS T3 C18 operated at 40°C. Flow rate was 0.5 ml.min⁻¹. Solvents used were 10 mM NH₄CH₃COO in water set to pH 9.0 with NH₃ (Eluent A), Acetonitrile (B) and THF (C). Two binary gradients were applied from 80/20 A/B to 1/99 A/B in 10 minutes and from 1/99 A/B to 1/49/50 A/B/C in 5 minutes, after which starting conditions are applied (80/20 A/B). Assuming linear MS response of all components over all response ranges and an equal ionization efficiency for all components, Total Ion Current signals were integrated. In case of coelution extracted ion chromatograms of that particular species were integrated. Dividing the integrated signal of a particular low-molecular weight peak by the total integrated sample signal yields the fraction of that low molecular weight species.

MALDI-ToF-MS

All MALDI-ToF-MS spectra were acquired using a Bruker Ultraflex extreme MALDI-ToF mass spectrometer. The instrument is equipped with a Nd:YAG laser emitting at 1064 nm and a collision cell (not used for these samples). Spectra were acquired in the positive-ion mode using the reflectron, using the highest resolution mode providing accurate masses (range 60-7000 m/z). Cesium Tri-iodide (range 0.3-3.5 kDa) was used for mass calibration (calibration method: IAV Molecular Characterisation, code MC-MS-05). The laser energy was 20%. The samples were dissolved in THF at approx. 50 mg/mL. The matrix used was: DCTB (trans-2-[3-(4-tert-Butylphenyl)-2-methyl-2-propenylidene]malononitrile), CAS Number 300364-84-5. The matrix solution was prepared by dissolving 20 mg in 1 mL of THF.

Sodium iodide was used as salt (NaI, CAS Number 7681-82-5); 10 mg was dissolved in 1 ml THF with a drop of MeOH added. Ratio sample:matrix:salt = 10:200:10 (µl), after mixing, 0.5 µL was spot on MALDI plate and allowed to air-dry. The peaks measured in the MALDI spectrum are sodium adducts of multi-aziridine compounds, and in the context of this specification the molecular weight (MW) of the multi-aziridine compound corresponds to $MW = \text{Obs. } [M + M_{\text{cation}}] - M_{\text{cation}}$, where Obs. $[M + M_{\text{cation}}]$ is the MALDI-

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TOF MS peak and M_{cation} is the exact mass of the cation used for making the adduct (in this case sodium with $M_{\text{cation}}=23.0$ Da). Multi-aziridine compounds can be identified by comparing the MW with the exact molecular mass (*i.e.* the sum of the – non-isotopically averaged – atomic masses of its constituent atoms) of a theoretical structure, using a
5 maximum deviation of 0.6 Da.

Genotoxicity testing

Genotoxicity of was evaluated by the ToxTracker® assay (Toxys, Leiden, the
10 Netherlands). The ToxTracker assay is a panel of several validated Green Fluorescent Protein (GFP)-based mouse embryonic stem (mES) reporter cell lines that can be used to identify the biological reactivity and potential carcinogenic properties of newly developed compounds in a single test. This methodology uses a two step-approach.

15 In the first step a dose range finding was performed using wild-type mES cells (strain B4418). 20 different concentrations for each compound was tested, starting at 10 mM in DMSO as highest concentration and nineteen consecutive 2-fold dilutions.

Next, genotoxicity of was evaluated using specific genes linked to reporter genes for the detection of DNA damage; *i.e.* Bsc12 (as elucidated by US9695481B2 and
20 EP2616484B1) and Rtkn (Hendriks *et. al.* Toxicol. Sci. **2015**, *150*, 190-203) biomarkers. Genotoxicity was evaluated at 10, 25 and 50% cytotoxicity in absence and presence of rat S9 liver extract-based metabolizing systems (aroclor1254-induced rats, Moltox, Boone, NC, USA). The independent cell lines were seeded in 96-well cell culture plates, 24 h after seeding the cells in the 96-well plates, fresh ES
25 cell medium containing the diluted test substance was added to the cells. For each tested compound, five concentrations are tested in 2-fold dilutions. The highest sample concentration will induce significant cytotoxicity (50-70%). In case of no or low cytotoxicity, 10 mM or the maximum soluble mixture concentration is used as maximum test concentration. Cytotoxicity is determined by cell count after 24 h
30 exposure using a Guava easyCyte 10HT flow cytometer (Millipore).

GFP reporter induction is always compared to a vehicle control treatment. DMSO concentration is similar in all wells for a particular compound and never exceeds 1%. All compounds were tested in at least three completely independent repeat experiments. Positive reference treatment with cisplatin (DNA damage) were included

in all experiments. Metabolic was evaluated by addition of S9 liver extract. Cells are exposed to five concentrations of the test compound in the presence of S9 and required co-factors (RegenSysA+B, Moltox, Boone, NC, USA) for 3 h. After washing, cells are incubated for 24 h in fresh ES cell medium. Induction of the GFP reporters is determined after 24 h exposure using a Guava easyCyte 10HT flow cytometer (Millipore). Only GFP expression in intact single cells is determined. Mean GFP fluorescence and cell concentrations in each well is measured, which is used for cytotoxicity assessment. Data was analyzed using ToxPlot software (Toxys, Leiden, the Netherlands). The induction levels reported are at compound concentrations that induce 10%, 25% and 50% cytotoxicity after 3 h exposure in the presence of S9 rat liver extract and 24 h recovery or alternatively after 24 h exposure when not in the presence of S9 rat liver extract.

A positive induction level of the biomarkers is defined as equal to or higher than a 2-fold induction at at least one of 10, 25 and 50% cytotoxicity in the absence or presence of the metabolizing system rat S9 liver extract; a weakly positive induction as higher than 1.5-fold and lower than 2-fold induction at at least one of 10, 25 and 50% cytotoxicity (but lower than 2-fold at 10, 25 and 50% cytotoxicity) in the absence or presence of the metabolizing system rat S9 liver extract and a negative as lower than or equal to a 1.5-fold induction at 10, 25 and 50% cytotoxicity in the absence and presence of rat S9 liver extract-based metabolizing systems.

Components and abbreviations used:

- 2-Methylaziridine (propyleneimine, CAS No. 75-55-8) was obtained from Menadiona S.L. (Palafolls, Spain).
- n*-butylglycidyl ether (CAS No. 2426-08-6) was obtained from Alfa Aesar (a division of Thermo Fisher Scientific).
- Potassium carbonate (CAS No. 584-08-7) was obtained from Alfa Aesar (a division of Thermo Fisher Scientific).
- Bismuth neodecanoate (CAS No. 34364-26-6) obtained from TIB chemicals AG (Mannheim, Germany).
- 2-Methyltetrahydrofuran (CAS No. 96-47-9) was obtained from Merck KgaA.
- Desmodur® N3600, Desmodur® N3800, Desmodur® N3900 and Desmodur® XP2860 were obtained from Covestro.
- Acetone (CAS No. 67-64-1) was obtained from Sigma-Aldrich.
- Triethylamine (TEA, CAS No. 121-44-8) was obtained from Arkema.

- Maxemul™ 7101 was obtained from Croda Int. PLC.
Trimethylolpropane tris(2-methyl-1-aziridinepropionate), CAS No. 64265-57-2, CX-100 was obtained from DSM.
Atlas™ G-5000 was obtained from Croda Int. PLC.
- 5 Dimethylol propionic acid (DMPA, CAS No. 4767-03-7) was obtained from Perstop Polyols.
pTHF650 (polytetramethylene ether glycol with an OH-number of 172 mg KOH/g) obtained from BASF.
IPDI (5-Isocyanato-1-(isocyanatomethyl)-1,3,3-trimethylcyclohexane, Desmodur® I, 10 isophorone diisocyanate, CAS No. 4098-71-9) was obtained from Covestro.
Hydrazine (16% solution in water, CAS No. 302-01-2) was obtained from Honeywell.
Sodium lauryl sulphate (30% solution in water, CAS No. 73296-89-6) was obtained from BASF.
Methyl methacrylate (CAS No. 80-62-6) was obtained from Lucite Int.
- 15 *n*-Butyl acrylate (CAS No. 141-32-2) was obtained from Dow Chemical.
Methacrylic acid (CAS No. 79-41-4) was obtained from Lucite Int.
Ammonium persulphate (CAS No. 7727-54-0) was obtained from United Initiators.
Ammonia (25% solution in water, CAS No. 1336-21-6) was obtained from Merck.
Tin 2-ethylhexanoate (CAS No. 301-10-0) was obtained from Sigma-Aldrich.
- 20 Tegomer® D3403 was obtained from Evonik.
3-Methyl-1-phenyl-2-phospholene-1-oxide (CAS No. 707-61-9) was obtained from Sigma-Aldrich.
1-methoxy-2-propyl acetate (MPA, propylene glycol methyl ether acetate, CAS No. 108-65-6) was obtained from Shell Chemicals.
- 25 1-(2-hydroxyethyl)ethyleneimine (CAS No. 1072-52-2) was obtained from Tokyo Chemical Industry Co., Ltd.
DBTDL (dibutyltin dilaurate, CAS No. 77-58-7) was obtained from Reaxis.
Dimethylformamide (CAS No. 68-12-2) was obtained from Acros Organics (a division of Thermo Fisher Scientific).
- 30 Vestanat® T 1890/100, an isophorone diisocyanate based isocyanurate (CAS No. 67873-91-0) was obtained from Evonik.
Methylethylketone (MEK, 2-butanone, CAS No. 78-93-3) was obtained from Alfa Aesar (a division of Thermo Fisher Scientific).
Atlas™ G-5002L-LQ was obtained from Croda Int. PLC.

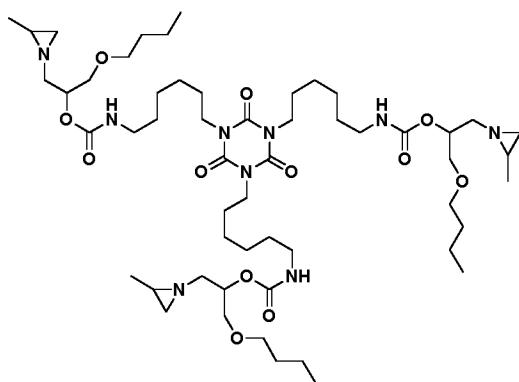
- 54 -

- 1-Butanol (CAS No. 71-36-3) was obtained from Sigma-Aldrich (a division of Merck KGaA).
- 2-Ethylhexyl glycidyl ether (CAS No. 2461-15-6) was obtained Sigma-Aldrich (a division of Merck KGaA).
- 5 H12MDI (4,4'-Methylenebis(phenyl isocyanate, Desmodur® W, CAS No. 101-66-8) was obtained from Covestro.
- Ymer™ N-120 was obtained from Perstorp.
- Potassium hydroxide (CAS No. 1310-58-3) was obtained from Sigma-Aldrich.
- Cardura E10P (CAS No. 26761-45-5) was obtained from Hexion Inc.
- 10 Polypropylene glycol with an average Mn of 400 Da (PPG400, Voranol™ P-400) was obtained from Dow Inc. and polypropylene glycol with an average Mn of 1000 Da (CAS No. 25322-69-4) was obtained from BASF.
- Toluene (CAS No. 108-88-3) was obtained from Sigma-Aldrich.
- Bisphenol A diglycidyl ether (CAS No. 1675-54-3) was obtained from Tokyo
- 15 Chemical Industry Co., Ltd.
- Ethyldiglycol (CAS No. 111-90-0) was obtained from Acros Organics (a division of Thermo Fisher Scientific).
- Texanol™ (CAS No. 25265-77-4) was obtained from Eastman.
- Butylglycol (CAS No. 111-76-2) was obtained from Sigma-Aldrich.
- 20 Butyldiglycol (CAS No. 112-34-5) was obtained from Alfa Aesar (a division of Thermo Fisher Scientific).
- Byk 347 was obtained from BYK.
- Borchi® Gel L 75 N was obtained from Borchers.
- NeoCryl® A-2092 was obtained from DSM.
- 25 NeoCryl® XK-12 was obtained from DSM.
- NeoCryl® XK-190 was obtained from DSM.
- NeoRad® R-520 was obtained from DSM.
- NeoPac™ PU-480 was obtained from DSM.
- NeoRez® R-600 was obtained from DSM.
- 30 NeoCryl® XK-82 was obtained from DSM.
- NeoRez® R-1888 was obtained from DSM.
- NeoCryl® XK-98 was obtained from DSM.
- NeoRez® R-1005 was obtained from DSM.
- 35 Example 1

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A 1 L round bottom flask equipped with a condenser was placed under a N₂ atmosphere and charged with propylene imine (120 gram), *n*-butyl glycidyl ether (189.0 gram) and K₂CO₃ (15.0 gram) and heated to 80°C in 30 min, after which the mixture was stirred for 21 h at T= 80°C. After filtration the excess of PI was removed *in vacuo*, followed by
5 further purification *via* vacuum distillation, resulting in a colorless low viscous liquid.

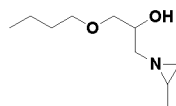
186.2 grams of the resulting material (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) was charged to a reaction flask equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and 77.8 grams of 2-methyltetrahydrofuran. The
10 mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 200 grams of Desmodur N 3600 in 77.8 grams of 2-methyltetrahydrofuran was then added dropwise in 45 minutes to the reaction flask, whereafter the mixture was heated further to 70°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR
15 spectrometer until no NCO-stretch at 2200-2300 cm⁻¹ was observed. The solvent was removed *in vacuo* to obtain a clear, yellowish highly viscous liquid. The calculated molecular weight of the theoretical main component was 1065.74 Da, chemical structure is shown below.



20 Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na⁺] = 1088.74 Da; Obs. [M + Na⁺] = 1088.78 Da. The following components with a mass below 580 Da were determined by LC-MS and quantified:



was present in the composition at 0.21 wt.% and



was present at less than 0.01 wt.%.

Genotoxicity test

	Without S9 rat liver extract						With S9 rat liver extract					
	Bsc1 2			Rtkn			Bsc1 2			Rtkn		
concentration	10	25	50	10	25	50	10	25	50	10	25	50
→												
Composition 1	1.1	1.1	1.1	0.8	0.8	0.6	1.0	1.0	0.9	0.9	0.8	0.6

5

The genotoxicity test results show that the crosslinker composition of Example 1 is non-genotoxic.

Subsequently, 300 grams of the viscous liquid obtained in the previous step was mixed with 150 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.5 grams of triethylamine (TEA) and then 30 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 300 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA to obtain crosslinker dispersion 1.

20

Genotoxicity test

	Without S9 rat liver extract						With S9 rat liver extract					
	Bsc1 2			Rtkn			Bsc1 2			Rtkn		
concentration	10	25	50	10	25	50	10	25	50	10	25	50
→												
Dispersion 1	1.0	1.1	1.1	1.3	1.3	1.3	1.1	1.2	1.2	0.9	1.2	1.2

The genotoxicity test results show that the dispersion of Example 1 is non-genotoxic.

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NeoCryl® A-2092, obtained from DSM, is a highly versatile poly(styrene-co-acrylate-co-methacrylate) dispersion with a hydrodynamic diameter of 106 nm and an acid value of 55.3 mgKOH/g solids. In order to create a coating composition, to 94 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over
 5 10 minutes added 18.5 grams of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed using
 10 spot tests on coating surfaces, based on procedures from the DIN 68861-1 standard, and viscosity measurements using a Brookfield DVE-LV viscometer (using the lowest of S62, S63 or S64 spindles, as allowed by the sample at 60 rpm). For these tests, the coating composition was stored in an oven at 50°C for 4 weeks. Every week, the viscosity of the coating composition was determined. Additionally, every week, a
 15 sample of this coating composition was filtered and applied to Leneta test cards using 100 µm wire rod applicators (Test 1). For reference, films were also cast from the same (aged) composition lacking the crosslinker dispersion (Test Blank). The films were dried for 1 hour at 25°C, then annealed at 50°C for 16 hours. Subsequently, a piece of cotton wool was soaked in 1:1 EtOH : demineralized water and placed on the
 20 film for 1 hour. After removal of the EtOH and 60 minutes recovery, the following results were obtained (a score of 1 indicates complete degradation of the film, 5 indicates no damage visible):

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 1 (mPa.s)	30	31	32	33	28
Test 1	3	3	3	3	3
Test Blank	1	1	1	1	1

Example 2

25 Crosslinker was synthesized and dispersed as Example 1.

To 280 grams of NeoCryl® A-2092 was gradually over 10 minutes added 110.2 grams of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer.

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After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 8.7.

Functional performance and stability of the coating composition were assessed as in
5 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 2 (mPa.s)	100	73	78	80	62
Test 2	4	n.d.	3	n.d.	3
Test Blank	1	n.d.	1	n.d.	1

Example 3

Crosslinker was synthesized and dispersed as Example 1.

10

NeoCryl® XK-12, obtained from DSM, is a highly resistant self-crosslinking poly(acrylate-co-methacrylate) with a hydrodynamic diameter of 111 nm and an acid value of 24.2 mgKOH/g solids. In order to create a coating composition, to 900 grams of NeoCryl® XK-12 was added 90 grams of ethyldiglycol under continuous stirring
15 with a propeller stirrer. To 280 grams of this mixture was gradually over 10 minutes added 45.5 grams of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 8.8.

20

Functional performance and stability of the coating composition were assessed as in
Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 3 (mPa.s)	428	413	348	415	392

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Test 3	5	n.d.	4	n.d.	4
Test Blank	3	n.d.	3	n.d.	3

Example 4

Crosslinker was synthesized and dispersed as Example 1.

- 5 NeoCryl® XK-190, obtained from DSM, is a block-resistant poly(acrylate-co-methacrylate) with a hydrodynamic diameter of 115 nm and an acid value of 38.9 mgKOH/g solids. In order to create a coating composition, to 900 grams of NeoCryl® XK-190 was added 9 grams of Texanol™ under continuous stirring with a propeller stirrer. To 280 grams of this mixture was gradually over 10 minutes added 71.2 grams
- 10 of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 9.1.

- Functional performance and stability of the coating composition were assessed as in
- 15 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 4 (mPa.s)	128	130	121	136	132
Test 4	5	n.d.	4	n.d.	4
Test Blank	1	n.d.	1	n.d.	1

Example 5

Crosslinker was synthesized and dispersed as Example 1.

20

- NeoRad® R-520, obtained from DSM, is a UV-curable poly(urethane-co-acrylate) with a hydrodynamic diameter of 79 nm and an acid value of 25.7 mgKOH/g solids. In order to create a coating composition, to 900 grams of NeoRad™ R-520 was added 27 grams of butylglycol under continuous stirring with a propeller stirrer. To 280
- 25 grams of this mixture was gradually over 10 minutes added 40.0 grams of the

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crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 8.2.

- 5 Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 5 (mPa.s)	150	140	253	850	734
Test 5	4	n.d.	3	n.d.	3
Test Blank	2	n.d.	1	n.d.	1

Example 6

- 10 Crosslinker was synthesized and dispersed as Example 1.

NeoPac™ PU-480 obtained from DSM is a fast-drying polyurethane-alkyd hybrid with a hydrodynamic diameter of 107 nm and an acid value of 18.5 mgKOH/g solids. In order to create a coating composition, to 900 grams of NeoPac™ PU-480 was gradually over 10 minutes added 32.9 grams of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 9.0.

- 20 Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 6 (mPa.s)	68	40	54	35	45
Test 6	4	n.d.	3	n.d.	3

Test Blank 1 n.d. 1 n.d. 1

Example 7

Crosslinker was synthesized and dispersed as Example 1.

5 NeoRez® R-600, obtained from DSM, is a polyurethane with excellent adhesion, with a hydrodynamic diameter of 49 nm and an acid value of 21.3 mgKOH/g. In order to create a coating composition, to 900 grams of NeoRez® R-600 was added 19 grams of ethyldiglycol under continuous stirring with a propeller stirrer. To 280 grams of this mixture was gradually over 10 minutes added 30.1 grams of the crosslinker
 10 dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 8.5.

Functional performance and stability of the coating composition were assessed as in
 15 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 7 (mPa.s)	48	33	29	34	46
Test 7	3	n.d.	3	n.d.	3
Test Blank	1	n.d.	1	n.d.	1

Example 8

Crosslinker was synthesized and dispersed as Example 1.

20 NeoCryl® XK-82, obtained from DSM, is a highly water-resistant poly(styrene-co-acrylate-co-methacrylate), with a hydrodynamic diameter of 134 nm and an acid value of 50.5 mgKOH/g solids. In order to create a coating composition, to 807 grams of NeoCryl® XK-82 was added 40.4 grams of ethyldiglycol and 40.4 grams of butylglycol
 25 under continuous stirring with a propeller stirrer. To 250 grams of this mixture was gradually over 10 minutes added 75.8 grams of the crosslinker dispersion 1, under

continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 9.1.

- 5 Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 8 (mPa.s)	155	n.d.	135	n.d.	146
Test 8	4	n.d.	5	n.d.	5
Test Blank	3	n.d.	3	n.d.	3

Example 9

Crosslinker was synthesized and dispersed as Example 1.

10

NeoRez® R-1888, obtained from DSM, is a hail-resistant polyurethane with a hydrodynamic diameter of 102 nm and an acid value of 22.8 mgKOH/g solids. In order to create a coating composition, to 280 grams of NeoRez® R-1888 was gradually over 10 minutes added 38.9 grams of the crosslinker dispersion 1, under
 15 continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 8.1.

- 20 Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 9 (mPa.s)	90	104	92	87	103

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Test 9	4	n.d.	4	n.d.	3
Test Blank	2	n.d.	2	n.d.	2

Example 10

Crosslinker was synthesized and dispersed as Example 1.

- 5 NeoCryl® XK-98, obtained from DSM, is a fast-drying self-crosslinking poly(acrylate-co-methacrylate) with a hydrodynamic diameter of 59 nm and an acid value of 18.0 mgKOH/g solids. In order to create a coating composition, to 900 grams of NeoCryl® XK-98 was added 28 grams of butyldiglycol under continuous stirring with a propeller stirrer. To 280 grams of this mixture was gradually over 10 minutes added 40.5 grams
- 10 of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored. The pH of this coating composition was measured to be 8.2.

- Functional performance and stability of the coating composition were assessed as in
- 15 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 10 (mPa.s)	59	73	94	102	125
Test 10	5	n.d.	4	n.d.	4
Test Blank	2	n.d.	2	n.d.	2

Example 11

Crosslinker was synthesized and dispersed as Example 1.

20

In order to create a coating composition, to 65 grams of NeoCryl® XK-98, brought to pH = 10 with triethylamine (TEA), was first added 2.0 grams of butyldiglycol and subsequently gradually over 10 minutes added 5.5 grams of the crosslinker dispersion 1, under continuous stirring with a propeller stirrer. After addition, the

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coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in
5 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 11 (mPa.s)	85	64	60	78	120
Test 11	4	4	3	3	3
Test Blank	2	2	2	2	2

Example 12

Crosslinker was synthesized as Example 1.

10

Subsequently, 30 grams of the viscous liquid obtained in the previous step was mixed with 15 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 3.0 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5
15 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 30 grams of demineralized water, brought to pH 9 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved
20 around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 9 with TEA.

NeoRez® R-1005, obtained from DSM, is a flexible polyurethane with a hydrodynamic diameter of 62 nm and an acid value of 15.9 mgKOH/g solids. A
25 coating composition was created by adding 15 grams of the crosslinker dispersion obtained in the previous step dropwise to 158 grams of NeoRez® R-1005, which had been set to pH = 9 using TEA, under continuous stirring with a propeller stirrer. After

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addition, the coating composition was stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in
5 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity 12 (mPa.s)	210	190	164	386	1124
Test 12	5	5	5	5	4
Test Blank	1	1	1	1	1

Example 13

Crosslinker was synthesized as Example 1.

10

Subsequently, 30 grams of the viscous liquid obtained in the previous step was mixed with 15 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 3.0 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5
15 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 30 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting
20 dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

A coating composition was created by adding 15 grams of the crosslinker dispersion obtained in the previous step dropwise to 158 grams of NeoRez® R-1005, which had
25 been set to pH = 10 using TEA, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored.

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Functional performance and stability of the coating composition were assessed as in Example 1.

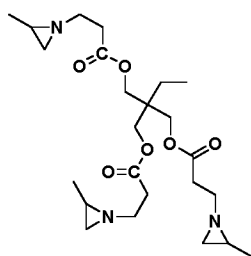
Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 13 (mPa.s)	284	256	1182	9000	-*
Test 13	5	5	5	5	-*
Test Blank	1	1	1	1	-*

5 *Coating composition gelled during fourth week of storage

Comparative Example C1

For Comparative Example C1, crosslinker CX-100 - trimethylolpropane tris(2-methyl-1-aziridinepropionate) - was used:



10

Of this crosslinker, 7.5 grams was mixed with 3.75 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine and then 0.75 grams of molten Atlas™ G-5000 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 7.5 grams of demineralized water, brought to pH 9 using triethylamine (TEA), was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting mixture was stirred at 5,000 rpm for 10 more minutes, and the pH of the mixture was set to 9.

20

A coating composition was created by adding 6 grams of the crosslinker mixture obtained in the previous step dropwise to 158 grams of NeoRez® R-1005, which had

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been set to pH = 9 using TEA, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored.

- 5 Functional performance and stability of the coating composition were assessed using spot tests on coating surfaces, based on procedures from the DIN 68861-1 standard, and viscosity measurements using a Brookfield DVE-LV viscometer (using the lowest of S62, S63 or S64 spindles, as allowed by the sample at 60 rpm). For these tests, the coating composition was stored in an oven at 50°C for 4 weeks. Every week, the
- 10 viscosity of the coating composition was determined. Additionally, every week, a sample of this coating composition was filtered and applied to Leneta test cards using 100 µm wire rod applicators (Test C1). For reference, films were also cast from the same (aged) composition lacking the crosslinker dispersion (Test Blank). The films were dried for 1 hour at 25°C, then annealed at 50°C for 16 hours. Subsequently, a
- 15 piece of cotton wool was soaked in 1:1 EtOH : demineralized water and placed on the film for 1 hour. After removal of the EtOH and 60 minutes recovery, the following results were obtained (a score of 1 indicates complete degradation of the film, 5 indicates no damage visible):

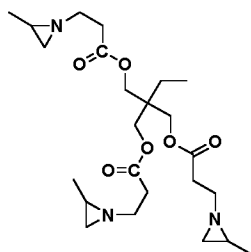
Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity C1 (mPa.s)	140	47100	-*	-*	-*
Test C1	5	3	-*	-*	-*
Test Blank	1	1	1	1	1

- 20 * Coating composition gelled during second week of storage

Comparative Example C2

For Comparative Example C2, crosslinker CX-100 - trimethylolpropane tris(2-methyl-1-aziridinepropionate) - was used:



Of this crosslinker, 7.5 grams was mixed with 3.75 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine and then 0.75 grams of molten Atlas™ G-5000 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 7.5 grams of demineralized water, brought to pH 10 using triethylamine (TEA), was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting mixture was stirred at 5,000 rpm for 10 more minutes, and the pH of the mixture was set to 10.

A coating composition was created by adding 6 grams of the crosslinker mixture obtained in the previous step dropwise to 158 grams of NeoRez® R-1005, which had been set to pH = 10 using TEA, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in Comparative Example C1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity C2 (mPa.s)	178	19620	-*	-*	-*
Test C2	5	3	-*	-*	-*
Test Blank	1	1	1	1	1

*Coating composition gelled during second week of storage

Example 14

Crosslinker was synthesized and dispersed as Example 1.

In order to create a coating composition, to 250 grams of NeoRez® R-1005 was
 5 gradually over 10 minutes added 10.7 grams of the crosslinker dispersion 1 obtained
 earlier, under continuous stirring with a propeller stirrer. After addition, the coating
 composition was stirred for a further 5 minutes, filtered and stored. The pH of this
 coating composition was measured to be 10.1.

10 Functional performance and stability of the coating composition were assessed as in
 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 14 (mPa.s)	175	132	212	170	746
Test 14	4	n.d.	4	n.d.	3
Test Blank	1	n.d.	1	n.d.	1

Example 15

15 Crosslinker was synthesized and dispersed as Example 1.

A waterborne polyurethane binder was synthesized as follows.

A 1 L flask equipped with a thermometer and overhead stirrer was charged with DMPA
 (12.9 grams), pTHF650 (168.4 grams) and IPDI (140.5 grams). The reaction mixture
 20 was placed under N₂ atmosphere, heated to 50°C and 0.03 g of bismuth neodecanoate
 was added. The mixture was allowed to exotherm and kept at 90°C for 2.5 hours. The
 NCO content of the resultant urethane prepolymer was 8.00% on solids (theoretically
 8.80%). The prepolymer was cooled down to 75°C and TEA (8.73 grams) was added
 and the resulting mixture was stirred for 15 minutes. A dispersion of the resultant
 25 prepolymer was made by feeding 290 gram of this prepolymer to demineralized water
 (686 grams) at room temperature in 30 minutes. After the feed was completed, the
 mixture was stirred for 5 minutes and hydrazine (16% solution in water, 51.0 grams)
 was added. The dispersion was stirred for a further 1 h. Subsequently, the mixture was

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cooled to room temperature and brought to 30% solids with further demineralized water.

The waterborne polyurethane binder was formulated as follows. An amount of 200 grams of the binder was first set to pH = 10 using TEA. Then, 8.4 grams of
 5 butyldiglycol was added dropwise under continuous stirring with a propeller stirrer, followed by 0.25 grams of Byk 347 and 0.50 grams of a mixture of Borch® Gel L 75 N (1 part by weight) and water (5 parts by weight). After these additions, the coating composition was stirred for a further 5 minutes, filtered and stored.

10 A coating composition was created by adding 4.6 grams of the crosslinker dispersion 1 obtained earlier dropwise to 158 grams of the waterborne polyurethane formulation obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and
 15 stored.

Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 15 (mPa.s)	10	12	20	22	49
Test 15	5	5	5	4	4
Test Blank	3	3	3	3	3

20 Example 16

Crosslinker was synthesized and dispersed as Example 1.

A waterborne polyacrylate-co-methacrylate binder was synthesized as follows.

A 2 L four-necked flask equipped with a thermometer and overhead stirrer was charged
 25 with sodium lauryl sulphate (30% solids in water, 8.38 grams of solution) and demineralized water (641 grams). The reactor phase was placed under N₂ atmosphere and heated to 82°C. A mixture of demineralized water (101 grams), sodium lauryl

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sulphate (30% solids in water, 33.5 grams of solution), methyl methacrylate (209.8 grams), *n*-butyl acrylate (403.2 grams) and methacrylic acid (15.72 grams) was placed in a large feeding funnel and emulsified with an overhead stirrer (monomer feed). Ammonium persulphate (1.58 grams) was dissolved in demineralized water (80.8 grams) and placed in a small feeding funnel (initiator feed). Ammonium persulphate (1.58 grams) was dissolved in demineralized water (9.5 grams), and this solution was added to the reactor phase. Immediately afterwards, 5% by volume of the monomer feed was added to the reactor phase. The reaction mixture then exothermed to 85°C and was kept at 85°C for 5 minutes. Then, the residual monomer feed and the initiator feed were fed to the reaction mixture over 90 minutes, maintaining a temperature of 85°C. After completion of the feeds, the monomer feed funnel was rinsed with demineralized water (17.0 grams) and reaction temperature maintained at 85°C for 45 minutes. Subsequently, the mixture was cooled to room temperature and brought to pH = 8.2 with ammonia solution (6.25 wt.% in demineralized water), and brought to 40% solids with further demineralized water.

In order to create a coating composition, to 150 grams of waterborne polyacrylate-co-methacrylate binder obtained as described above, was gradually over 10 minutes added 17.1 grams of the crosslinker dispersion 1 obtained earlier, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in Example 1.

25

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 16 (mPa.s)	33	30	35	42	55
Test 16	3	3	3	3	3
Test Blank	1	1	1	1	1

Comparative Example C3

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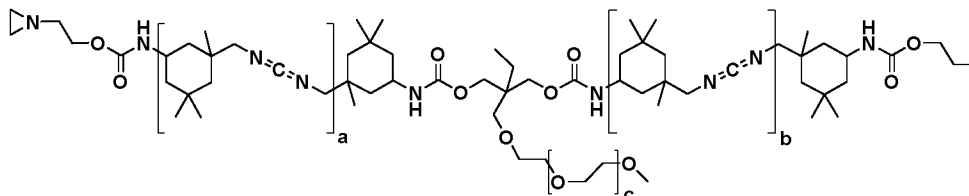
Under a nitrogen atmosphere, 21.3 grams of 1-propanol was added over a period of 6 hours to 78.7 grams of isophorone diisocyanate (IPDI) and 0.01 grams of tin 2-ethyl hexanoate at 20-25°C, while stirring. After standing overnight, 196.3 grams of IPDI, 74.1 grams of Tegomer D3403 and 2.4 grams of 3-Methyl-1-phenyl-2-phospholene-1-oxide were added. The mixture was heated to 150°C while stirring. The mixture was kept at 150°C until NCO content was 7.0 wt%. Mixture was cooled to 80°C and 333 grams of 1-methoxy-2-propyl acetate (MPA) was added. A solution of isocyanate functional polycarbodiimide was obtained with a solid content of 50.6 wt% and an NCO content of 7.0 wt% on solids.

10

To 100 grams of this isocyanate functional polycarbodiimide was added 7.0 grams of 1-(2-hydroxyethyl)ethyleneimine. One drop of dibutyltin dilaurate was added. The mixture was heated to 80°C while stirring. The mixture was kept at 80°C for 1 hour. FTIR showed a small remaining isocyanate signal, which disappeared after a few days. The solution was further diluted with 8.0 grams of MPA, resulting in a yellow solution with a solid content of 50.4 wt%. This aziridine functional carbodiimide contains 3.2 meq acid reactive groups (i.e aziridine and carbodiimide functionality) per gram solids.

15

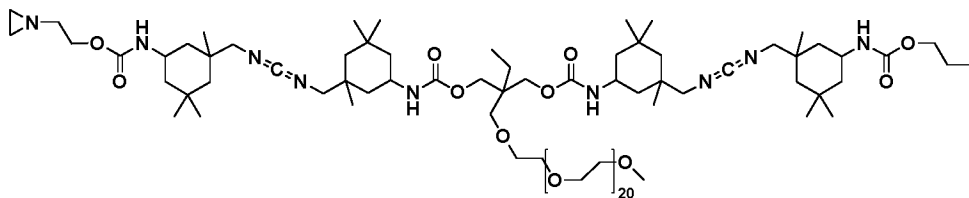
The generalized structure of this carbodiimide is depicted below.



20

in which a, b and c indicates repeating units.

This generalized structure was confirmed by MALDI-TOF-MS, an example is shown below:



25

Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na+] = 2043.34 Da;
 Obs. [M + Na+] = 2043.32 Da.

Genotoxicity test results:

	Without S9 rat liver extract						With S9 rat liver extract					
	Bsc1 2			Rtkn			Bsc1 2			Rtkn		
concentration	10	25	50	10	25	50	10	25	50	10	25	50
→												
Composition C3	1.3	1.5	1.6	1.2	1.9	1.9	1.2	1.4	1.5	2.0	2.0	1.8

5 The genotoxicity test results demonstrate that the crosslinker composition of Comparative Example C3 is genotoxic.

Subsequently, 10.5 grams of the yellow solution obtained in the previous step was stirred for at room temperature using a three-bladed propeller stirrer with diameter 50 mm at 500 rpm. Then, 10.5 grams of demineralized water was added gradually to the mixture over 15 minutes. After completion of the addition, the resulting dispersion was stirred at 1000 rpm for 5 more minutes.

A coating composition was created by adding 18.8 grams of the crosslinker dispersion obtained in the previous step dropwise to 75 grams of NeoRez® R-1005 under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in Example 1.

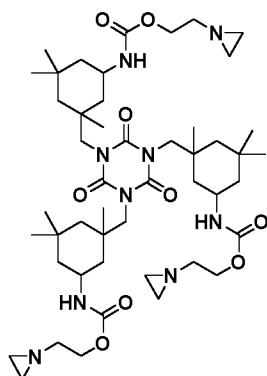
Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity C3 (mPa.s)	2064	_*	_*	_*	_*
Test C3	4	_*	_*	_*	_*
Test Blank	1	1	1	1	1

*Coating composition gelled during first week of storage

Comparative Example C4

13.6 grams of 1-(2-hydroxyethyl)ethyleneimine was charged to a reaction flask
5 equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and
147 grams of dimethylformamide. The mixture was stirred with a mechanical upper
stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 40.0 grams of
Vestanat T1890/100 in 147 grams of dimethylformamide was then added dropwise in
45 minutes to the reaction flask, followed by flushing with a further 10.0 grams of
10 dimethylformamide, whereafter the mixture was heated further to 70°C. Samples
were taken at regular intervals and the reaction progress was monitored using a
Bruker Alpha FT-IR spectrometer until no NCO-stretch at 2200-2300 cm⁻¹ was
observed. The solvent was removed *in vacuo* to obtain a whitish solid. The calculated
molecular weight of the theoretical main component was 927.62 Da, chemical
15 structure is shown below.



Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na⁺] = 950.61 Da;
Obs. [M + Na⁺] = 950.50 Da.

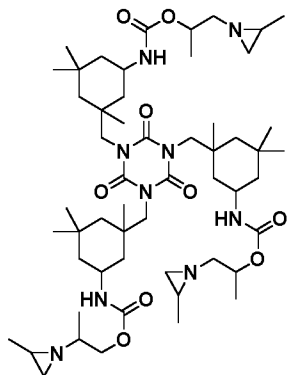
20 Subsequently, 15 grams of the whitish solid obtained in the previous step was mixed
with 7.5 grams of acetone and incubated at 50°C until a homogeneous solution was
obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.5
grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5
minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25
25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 15 grams
of demineralized water, brought to pH 10 using triethylamine, was added gradually to
the mixture over 15 minutes. During this addition process, the mixer was moved
around the reaction vessel continuously. After completion of the addition, the resulting

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dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA. Within 4 hours after conclusion of this 1-(2-hydroxyethyl)ethyleneimine based preparation, the resulting dispersion had coagulated. Therefore, no aqueous coating composition with good crosslinking efficiency and a longer shelf-life could be prepared.

Example 17

15.6 grams of 1-(2-methylaziridin-1-yl)propan-2-ol (prepared according to S. Lesniak, M. Rachwalski, S. Jarzynski, E. Obijalska *Tetrahedron Asymm.* **2013**, *24* 1336-1340) was charged to a reaction flask equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and 81.4 grams of dimethylformamide. The mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 34.5 grams of Vestanat T1890/100 in 200 grams of dimethylformamide was then added dropwise in 45 minutes to the reaction flask, whereafter the mixture was heated further to 70°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no NCO-stretch at 2200-2300 cm⁻¹ was observed. The solvent was removed *in vacuo* to obtain a whitish solid. The calculated molecular weight of the theoretical main component was 1011.71 Da, chemical structure is shown below.



Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na⁺] = 1034.70 Da; Obs. [M + Na⁺] = 1034.66 Da.

Subsequently, 9.4 grams of the yellowish viscous liquid obtained in the previous step was mixed with 3.4 grams of acetone and 1.3 grams of methylethylketone (MEK) and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.9 grams of Atlas™ G-5002L-LQ dispersant. The resulting mixture was stirred for 5 minutes at room temperature using

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an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 9.4 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel

5 continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

In order to create a coating composition, to 75 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 14.1 grams of

10 the crosslinker dispersion obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in

15 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 17 (mPa.s)	70	60	58	87	156
Test 17	3	3	3	3	3
Test Blank	1	1	1	1	1

Example 18

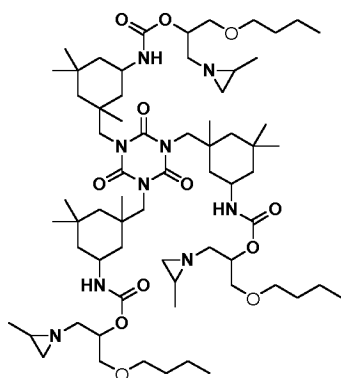
24.12 grams of the (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) intermediate

20 prepared as described in Example 1 was charged to a reaction flask equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and 4.48 grams of acetone. The mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 34.0 grams of Vestanat T1890/100 in 12.80 grams of acetone was then added dropwise in 25 minutes to the reaction flask,

25 whereafter the mixture was further reacted at 50°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no change in NCO-stretch at 2200-2300 cm⁻¹ was observed. Subsequently, 0.83 grams of 1-butanol were added to the mixture, followed by further

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reaction to complete disappearance of aforementioned NCO-stretch peak. Finally, the solvent was removed *in vacuo* to obtain a yellowish highly viscous liquid. The calculated molecular weight of the theoretical main component was 1227.88 Da, chemical structure is shown below.



5

Subsequently, 9.4 grams of the yellowish viscous liquid obtained in the previous step was mixed with 2.0 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.0 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 9.5 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

In order to create a coating composition, to 80 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 16.2 grams of the crosslinker dispersion obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

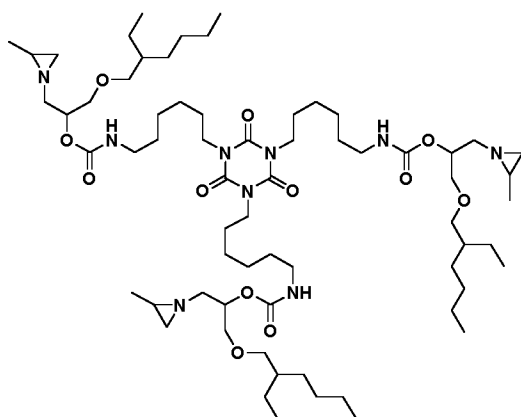
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Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 18 (mPa.s)	52	50	42	40	39
Test 18	3	3	3	3	2
Test Blank	1	1	1	1	1

Example 19

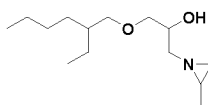
A 1 L round bottom flask equipped with a condenser was placed under a N₂ atmosphere and charged with propylene imine (91.0 gram), 2-ethylhexylglycidyl ether (201.0 gram) and K₂CO₃ (10.00 gram) and heated to 80°C, after which the mixture was stirred for 47 h at T= 80°C. After filtration the excess of PI was removed *in vacuo*, followed by further purification *via* vacuum distillation, resulting in a colorless low viscous liquid.

130 grams of the resulting material was charged to a reaction flask equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and 668 grams of dimethylformamide. The mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 107.4 grams of Desmodur N 3600 in 668 grams of dimethylformamide was then added dropwise in 45 minutes to the reaction flask, a further 10 grams of dimethylformamide was flushed through the feeding funnel into the reaction mixture, whereafter the mixture was heated further to 75°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no NCO-stretch at 2200-2300 cm⁻¹ was observed. The solvent was removed *in vacuo* to obtain a highly viscous colorless liquid. The calculated molecular weight of the theoretical main component was 1233.93 Da, chemical structure is shown below.



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Molecular weight was confirmed by Maldi-TOF-MS: Calcd. $[M + Na^+] = 1256.93$ Da; Obs. $[M + Na^+] = 1256.86$ Da. The following components with a mass below 580 Da were determined by LC-MS and quantified:



5 was present at 0.16 wt.%.

Subsequently, 15 grams of the viscous liquid obtained in the previous step was mixed with 7.5 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.5
 10 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 15 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved
 15 around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

A coating composition was created by adding 17 grams of the crosslinker dispersion
 20 obtained in the previous step dropwise to 158 grams of NeoRez® R-1005, which had been set to pH = 10 using TEA, under continuous stirring with a propeller stirrer. After addition, the coating composition was stirred for a further 5 minutes, filtered and stored.

25 Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 19 (mPa.s)	58	80	178	823	-*
Test 19	5	5	5	4	-*

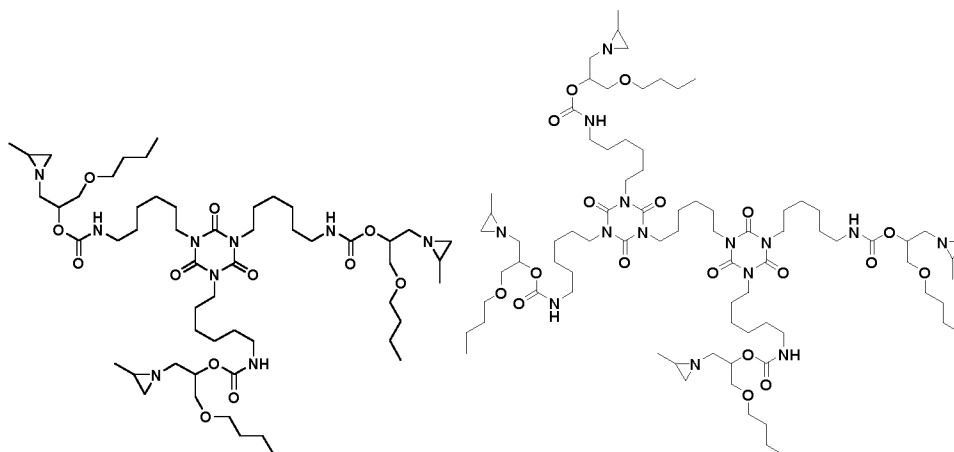
- 80 -

Test Blank	1	1	1	1	-*
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*Coating composition gelled during fourth week of storage

Example 20

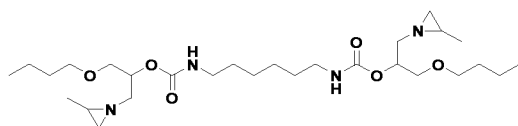
- 73.3 grams of (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol), synthesized as
- 5 described in Example 1, was charged to a reaction flask equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and 460 grams of dimethylformamide. The mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 162.6 grams of Desmodur N 3800 in 460 grams of dimethylformamide was then added dropwise in 45 minutes to
- 10 the reaction flask, whereafter the mixture was heated further to 70°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no NCO-stretch at 2200-2300 cm⁻¹ was observed. The solvent was removed *in vacuo* to obtain a clear, yellowish highly viscous liquid.
- 15 The calculated molecular weight of the theoretical main components were 1065.74 Da (three aziridine groups) and 1589.08 (four aziridine groups), chemical structures are shown below.



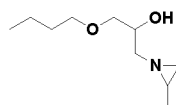
- Molecular weight were confirmed by Mald-TOF-MS: Calcd. [M + Na⁺] = 1088.74 Da;
- 20 Obs. [M + Na⁺] = 1088.79 Da (three aziridine groups). Calcd. [M + Na⁺] = 1612.07 Da; Obs. [M + Na⁺] = 1612.19 Da (four aziridine groups).

The following components with a mass below 580 Da were determined by LC-MS and quantified:

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was present in the composition at 0.31 wt.% and



was present at less than 0.01 wt.%.

5

Subsequently, 11.1 grams of the viscous liquid obtained in the previous step was mixed with 4.8 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.1 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred
10 for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 11.1 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the
15 resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

In order to create a coating composition, to 100 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 22.0 grams
20 of the crosslinker dispersion obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in
25 Example 1.

Performance and stability test

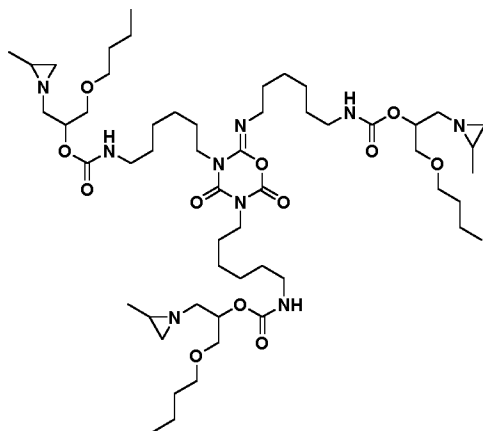
Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 20 (mPa.s)	66	42	42	48	64

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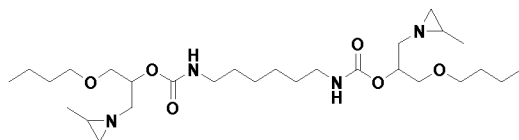
Test 20	3	3	3	3	3
Test Blank	1	1	1	1	1

Example 21

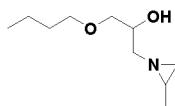
The (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) intermediate was prepared as described in Example 1, and 9.6 grams were charged to a reaction flask equipped with a thermometer, together with 0.02 grams of bismuth neodecanoate and 30 grams of 2-methyltetrahydrofuran. The mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. A solution of 10 grams of Desmodur N 3900 in 30 grams of 2-methyltetrahydrofuran was then added dropwise in 45 minutes to the reaction flask, whereafter the mixture was heated further to 70°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no change in NCO-stretch at 2200-2300 cm⁻¹ was observed. Subsequently, 0.33 grams of 1-butanol were added to the mixture, followed by further reaction to complete disappearance of aforementioned NCO-stretch peak. The solvent was removed *in vacuo* to obtain a clear, yellowish highly viscous liquid. The calculated molecular weight of the theoretical main component was 1065.74 Da, chemical structure is shown below.



Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na⁺] = 1088.74 Da; Obs. [M + Na⁺] = 1088.81 Da. The following components with a mass below 580 Da were determined by LC-MS and quantified:



was present in the composition at 0.30 wt.% and



was present at 0.02 wt.%.

5 Genotoxicity test

	Without S9 rat liver extract						With S9 rat liver extract					
	Bsci 2			Rtkn			Bsci 2			Rtkn		
concentration	10	25	50	10	25	50	10	25	50	10	25	50
→												
Composition 21	1.1	1.1	0.9	1.1	1.0	0.9	1.0	0.9	0.7	1.1	1.0	0.9

The genotoxicity test results show that the crosslinker composition of Example 21 is non-genotoxic.

10 Subsequently, 14.4 grams of the viscous liquid obtained in the previous step was mixed with 7.2 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.5 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with
 15 S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 14.4 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the
 20 dispersion was set to 10 with TEA.

In order to create a coating composition, to 150 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 22.6 grams of the crosslinker dispersion obtained in the previous step, under continuous stirring
 25 with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

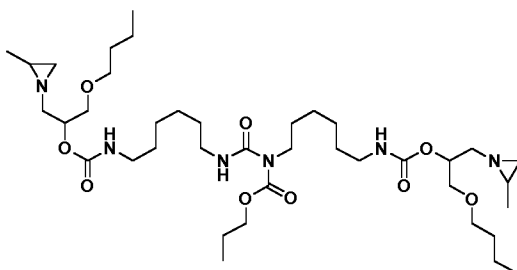
Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 21 (mPa.s)	62	41	50	44	45
Test 21	3	3	3	3	3
Test Blank	1	1	1	1	1

5 Example 22

20 grams of Desmodur XP 2860 and 0.02 grams of bismuth neodecanoate were charged to a reaction flask equipped with a thermometer. The mixture was stirred with a mechanical upper stirrer under a nitrogen atmosphere and heated to 50°C. 16.40 grams of (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) intermediate prepared as described in Example 1 was then added dropwise in 10 minutes to the reaction flask, whereafter the mixture was heated further to 70°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no change in NCO-stretch at 2200-2300 cm⁻¹ was observed. Subsequently, 0.16 grams of 1-butanol were added to the mixture, followed by further reaction to complete disappearance of aforementioned NCO-stretch peak. The product was a yellowish translucent highly viscous liquid. The calculated molecular weights of the theoretical main components were 770.55 Da (propyl side group), 784.57 Da (butyl side group) and 798.58 Da (pentyl side group), chemical structures are shown below.



20

Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na⁺] = 793.55 Da; Obs. [M + Na⁺] = 793.57 Da.

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The genotoxicity test results show that the crosslinker composition of Example 22 only has weakly positive induced genotoxicity.

Subsequently, 21.5 grams of the yellowish viscous liquid obtained in the previous step was mixed with 10.7 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 3.2 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 21.4 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

15

In order to create a coating composition, to 60 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 13.8 grams of the crosslinker dispersion obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

20

Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 22 (mPa.s)	83	58	66	42	50
Test 22	3	3	3	3	3
Test Blank	1	1	1	1	1

25

Example 23

A 500 mL round bottom flask equipped with a thermometer and overhead stirrer was placed under a N₂ atmosphere and charged with Desmodur W (54.67 gram) and

39.03 gram of (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) intermediate prepared as described in Example 1. The resulting mixture was heated to 50°C, after which bismuth neodecanoate (0.05 gram) was added. The mixture was allowed to exotherm followed by further heating to 70°C and stirring for 1 hour at 65°C. To the mixture was
 5 then added 41.67 grams of a polypropylene glycol with an average Mn of 400 Da (PPG400) and the mixture was stirred for another 1 hour at 80°C. The solvent was removed *in vacuo* to obtain a colorless solid.

Subsequently, 11.2 grams of the yellowish viscous liquid obtained in the previous
 10 step was mixed with 5.6 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 2.2 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was
 15 increased to 10,000 rpm and 11.2 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

20 In order to create a coating composition, to 60 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 21.7 grams of the crosslinker dispersion obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with
 25 TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 23 (mPa.s)	89	84	74	78	60
Test 23	4	4	4	4	3

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Test 24	3	3	3	3	3
Test Blank	1	1	1	1	1

Example 25

A 1 L round bottom flask equipped with a condenser was placed under a N₂ atmosphere and charged with propylene imine (69.0 gram), Cardura E10P (201.0 gram) and K₂CO₃ (7.30 gram) and heated to 80°C, after which the mixture was stirred for 24 h at T= 80°C.

- 5 After filtration the excess of PI was removed *in vacuo*, resulting in a colorless low viscous liquid.

A 500 mL round bottom flask equipped with a thermometer and overhead stirrer was placed under a N₂ atmosphere and charged with Desmodur W (49.56 gram) and 53.91 gram of the product of the previous step. The resulting mixture was heated to 50°C, after which bismuth neodecanoate (0.02 gram) was added. The mixture was allowed to exotherm followed by further heating to 80°C and stirring for 2.5 hours at 80°C. To the mixture was then added 96.48 grams of a polypropylene glycol with an average Mn of 1000 Da (PPG1000) and the mixture was stirred for another 1 hour at 80°C. The solvent was removed *in vacuo* to obtain a colorless solid.

Subsequently, 15 grams of the colorless solid obtained in the previous step was mixed with 7.5 grams of acetone and incubated at 50°C until a homogeneous solution was obtained. To this solution was added 0.03 grams of triethylamine (TEA) and then 1.5 grams of molten Maxemul™ 7101 dispersant. The resulting mixture was stirred for 5 minutes at room temperature using an IKA T25 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was increased to 10,000 rpm and 15 grams of demineralized water, brought to pH 10 using triethylamine, was added gradually to the mixture over 15 minutes. During this addition process, the mixer was moved around the reaction vessel continuously. After completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10 more minutes, and the pH of the dispersion was set to 10 with TEA.

In order to create a coating composition, to 60 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 34.1 grams of the crosslinker dispersion obtained in the previous step, under continuous stirring with

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a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in
5 Example 1.

Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 25 (mPa.s)	80	56	66	66	60
Test 25	4	4	4	3	3
Test Blank	1	1	1	1	1

Example 26

A 2 L round bottom flask equipped with a condenser was placed under a N₂ atmosphere
10 and charged with toluene (250 gram), propylene imine (325 gram), Bisphenol A-diglycidyl ether (387 gram) and K₂CO₃ (10.0 gram) and heated to 70°C in 30 min, after which the mixture was stirred for 19 h at T= 70°C. After filtration the excess of PI was removed *in vacuo*, followed by further purification *via vacuum distillation*, resulting in a whitish solid.

15

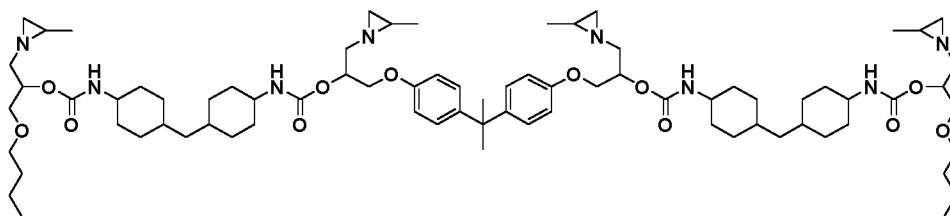
A 500 mL round bottom flask equipped with a thermometer and overhead stirrer was placed under a N₂ atmosphere and charged with the Bisphenol A-PI intermediate prepared as described above (24.85 gram), (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) intermediate prepared as described in Example 1 (18.65 gram), Desmodur W
20 (33.39 gram) and 22.90 grams of acetone. The resulting mixture was heated to 50°C, after which bismuth neodecanoate (0.02 gram) was added. The mixture was allowed to exotherm to 60°C followed by stirring for 120 minutes at 60°C. Samples were taken at regular intervals and the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no change in NCO-stretch at 2200-2300 cm⁻¹ was observed.
25 Subsequently, 23.02 grams of Ymer N120 was added to the reaction mixture. The reaction mixture was then further reacted to complete disappearance of aforementioned NCO-stretch peak, and then 25.00 grams of acetone were added to dilute the reaction mixture. Subsequently, the mixture was cooled to 40°C and 166

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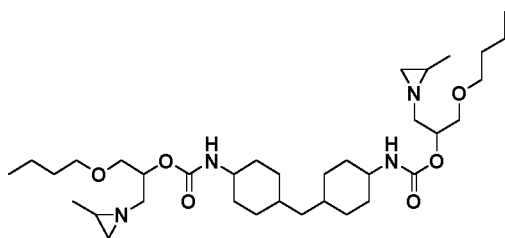
grams of demineralized water was added gradually, yielding a bluish dispersion. The acetone was then removed from the dispersion using a rotary evaporator, and finally the pH of the dispersion was set to 12.5 using a 15% aqueous solution of potassium hydroxide.

5

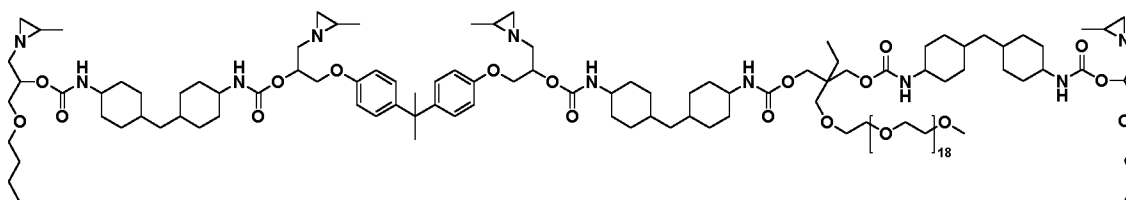
The calculated molecular weights of the theoretical main components and their chemical structures are shown below:



Molecular weight was confirmed by Maldi-TOF-MS: Calcd. $[M + Na^+] = 1375.92$ Da;

10 Obs. $[M + Na^+] = 1375.91$ Da.

Molecular weight was confirmed by Maldi-TOF-MS: Calcd. $[M + Na^+] = 659.47$ Da;

Obs. $[M + Na^+] = 659.41$ Da.

15

Molecular weight was confirmed by Maldi-TOF-MS: Calcd. $[M + Na^+] = 2622.70$ Da;

Obs. $[M + Na^+] = 2622.59$ Da.

In order to create a coating composition, to 75 grams of NeoCryl® A-2092, brought to pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 15.7 grams of the crosslinker dispersion obtained in the previous step, under continuous stirring with a propeller stirrer. After addition, the coating composition was set to pH = 10 with TEA, stirred for a further 5 minutes, filtered and stored.

20

Functional performance and stability of the coating composition were assessed as in Example 1.

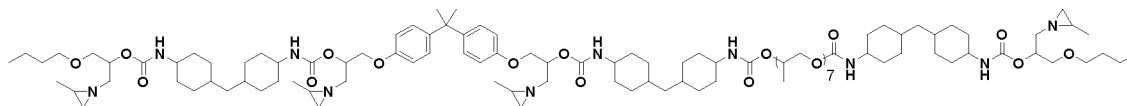
Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 26 (mPa.s)	60	80	71	89	91
Test 26	3	3	3	3	3
Test Blank	1	1	1	1	1

5

Example 27

A 500 mL round bottom flask equipped with a thermometer and overhead stirrer was placed under a N₂ atmosphere and charged with the Bisphenol A-PI intermediate prepared as described in Example 26 (17.13 gram), (1-butoxy-3-(2-methylaziridin-1-yl)propan-2-ol) intermediate prepared as described in Example 1 (28.24 gram),
 10 Desmodur W (39.55 gram) and 25.00 grams of acetone. The resulting mixture was heated to 60°C, after which bismuth neodecanoate (0.02 gram) was added. The mixture was kept at 60°C using a water bath throughout the exothermic reaction, followed by stirring for 2 hours at 60°C. Samples were taken at regular intervals and
 15 the reaction progress was monitored using a Bruker Alpha FT-IR spectrometer until no change in NCO-stretch at 2200-2300 cm⁻¹ was observed. Subsequently, 15.08 grams of Voranol P-400 was added to the reaction mixture. The reaction mixture was then further reacted to complete disappearance of aforementioned NCO-stretch peak. Finally, 20.00 grams of acetone were added to yield a light yellow solution. The
 20 calculated molecular weights of the theoretical main components and their chemical structures are shown below:



Molecular weight was confirmed by Maldi-TOF-MS: Calcd. [M + Na⁺] = 2062.40 Da;

25 Obs. [M + Na⁺] = 2062.39 Da.

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The genotoxicity test results show that the crosslinker composition of Example 27 only has weakly positive induced genotoxicity.

Subsequently, 36.5 grams of the yellow solution obtained in the previous step was
 5 mixed with 6.2 grams of methyl ethyl ketone (MEK) and incubated at 50°C until a
 homogeneous solution was obtained. To this solution was added 0.03 grams of
 triethylamine (TEA) and then 5.4 grams of molten Maxemul™ 7101 dispersant. The
 resulting mixture was stirred for 5 minutes at room temperature using an IKA T25
 Digital Ultra-Turrax® mixer with S 25 N - 18G head at 2,000 rpm. Then, stirring was
 10 increased to 10,000 rpm and 26.8 grams of demineralized water, brought to pH 10
 using triethylamine, was added gradually to the mixture over 15 minutes. During this
 addition process, the mixer was moved around the reaction vessel continuously. After
 completion of the addition, the resulting dispersion was stirred at 5,000 rpm for 10
 more minutes, and the pH of the dispersion was set to 10 with TEA.

15

In order to create a coating composition, to 75 grams of NeoCryl® A-2092, brought to
 pH = 10 with triethylamine (TEA), was gradually over 10 minutes added 14.0 grams of
 the crosslinker dispersion obtained in the previous step, under continuous stirring with
 a propeller stirrer. After addition, the coating composition was set to pH = 10 with
 20 TEA, stirred for a further 5 minutes, filtered and stored.

Functional performance and stability of the coating composition were assessed as in
 Example 1.

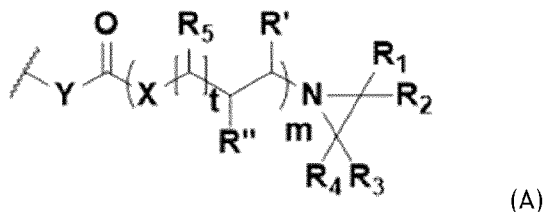
Performance and stability test

Sample	Week 0	Week 1	Week 2	Week 3	Week 4
Viscosity Ex. 27 (mPa.s)	101	68	77	71	99
Test 27	3	3	3	3	3
Test Blank	1	1	1	1	1

25

CLAIMS

1. An aqueous coating composition comprising a multi-aziridine compound and a carboxylic acid functional polymer, characterized in that
- 5 (i) the aqueous coating composition is an aqueous dispersion having a pH ranging from 8 to 14,
- (ii) the aqueous dispersion comprises particles X which particles X comprise multi-aziridine compound and particles Y which particles Y comprise carboxylic acid functional polymer, whereby the carboxylic acid functional
- 10 polymer contains carboxylic acid groups and/or carboxylate groups, and
- (iii) said multi-aziridine compound has:
- a) from 2 to 6 of the following structural units A:

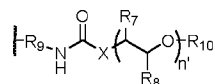


- whereby
- 15 R_1 is H,
- R_2 and R_4 are independently chosen from H or an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,
- R_3 is an aliphatic hydrocarbon group containing from 1 to 4 carbon atoms,
- 20 m is an integer from 1 to 6,
- R' and R'' are according to (1) or (2):
- (1) $R' = H$ or an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, and
- 25 $R'' = H$, an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms, a cycloaliphatic hydrocarbon group containing from 5 to 12 carbon atoms, an aromatic hydrocarbon group containing from 6 to 12 carbon atoms, $CH_2-O-(C=O)-R'''$, CH_2-O-R''' , or $CH_2-(OCR''''HCR''''H)_n-OR''''$, whereby R''' is an aliphatic hydrocarbon group containing from 1 to 14 carbon atoms and R'''' is an aliphatic
- 30 hydrocarbon group containing from 1 to 14 carbon atoms or an

- aromatic hydrocarbon group containing from 6 to 12 carbon atoms,
 n being from 1 to 35, R'''' independently being H or an aliphatic
 hydrocarbon group containing from 1 to 14 carbon atoms and R''''''
 being an aliphatic hydrocarbon group containing from 1 to 4 carbon
 5 atoms,
- (2) R' and R'' form together a saturated cycloaliphatic hydrocarbon
 group containing from 5 to 8 carbon atoms,
 t is an integer from 0 to 3,
 R₅ is H or CH₃,
- 10 X and Y are according to (I), (II) or (III):
- (I) X and Y are both N-R₆;
 (II) X is O and Y is N-R₆;
 (III) X is N-R₆ and Y is O,
 whereby R₆ is H or a linear or branched hydrocarbon group containing
 15 from 1 to 4 carbon atoms;
- b) one or more linking chains wherein each one of these linking chains
 links two of the structural units A, whereby a linking chain is the
 shortest chain of consecutive atoms that links two structural units
 A; and
- 20 c) a molecular weight in the range from 500 to 10000 Daltons, wherein
 the molecular weight is determined using MALDI-TOF mass
 spectrometry as described in the description.
2. The aqueous coating composition according to claim 1, characterized in that
 R₂ is H, R₃ is CH₃ and R₄ is H.
- 25 3. The aqueous coating composition according claim 1, wherein R₂ is H, R₃ is
 CH₃ and R₄ is CH₃.
4. The aqueous coating composition according to any of the preceding claims,
 characterized in that X is O, Y is NH, m is 1 and t is 0.
5. The aqueous coating composition according to any of the preceding claims,
 30 characterized in that the linking chains consist of from 4 to 300 atoms, more
 preferably from 5 to 250 and most preferably from 6 to 100 atoms and the
 linking chains are preferably a collection of atoms covalently connected which
 collection of atoms consists of i) carbon atoms, ii) carbon and nitrogen atoms,
 or iii) carbon, oxygen and nitrogen atoms.

6. The aqueous coating composition according to any of the preceding claims, characterized in that the multi-aziridine compound contains 2 or 3 structural units A.
7. The aqueous coating composition according to any of the preceding claims,
5 characterized in that
R' is H and R" = an alkyl group containing from 1 to 4 carbon atoms, CH₂-O-(C=O)-R''', CH₂-O-R''', or CH₂-(OCH₂CH₂)_n-OCH₃, whereby R''' is an alkyl group containing from 3 to 12 carbon atoms and R'''' is an alkyl group containing from 1 to 14 carbon atoms.
- 10 8. The aqueous coating composition according to any of the preceding claims, characterized in that the multi-aziridine compound comprises one or more connecting groups wherein each one of these connecting groups connects two of the structural units A, whereby the connecting groups consist of at least one functionality selected from:
15 aliphatic hydrocarbon functionality (preferably containing 1 to 8 carbon atoms), cycloaliphatic hydrocarbon functionality (preferably containing 4 to 10 carbon atoms), aromatic hydrocarbon functionality (preferably containing 6 to 12 carbon atoms), isocyanurate functionality, iminooxadiazindione functionality, urethane functionality, urea functionality, biuret functionality and any
20 combination thereof.
9. The aqueous coating composition according to claim 8, characterized in that the connecting groups consist of at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality and optionally at least one aromatic hydrocarbon functionality and optionally an
25 isocyanurate functionality or an iminooxadiazindione functionality.
10. The aqueous coating composition according to claim 8 or 9, characterized in that the connecting groups consist of at least one aliphatic hydrocarbon functionality and/or at least one cycloaliphatic hydrocarbon functionality and an isocyanurate functionality or an iminooxadiazindione functionality.
- 30 11. The aqueous coating composition according to any one of the preceding claims, characterized in that the multi-aziridine compound comprises one or more connecting groups wherein each one of these connecting groups connects two of the structural units A, wherein the connecting groups consist of (i) at least two aliphatic hydrocarbon functionality and (ii) an isocyanurate
35 functionality or an iminooxadiazindione functionality and wherein a pendant

group is present on a connecting group, whereby the pendant group has the following structural formula:



wherein

5 n' is the number of repeat units and is an integer from 1 to 50, preferably from 2 to 30, more preferably from 5 to 20.

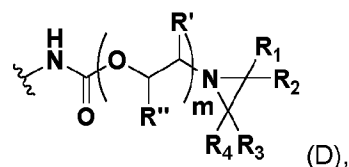
X is O or NH, preferably X is O,

R₇ and R₈ are independently H or CH₃ in each repeating unit,

10 R₉ is an aliphatic hydrocarbon group, preferably containing from 1 to 8 carbon atoms, and

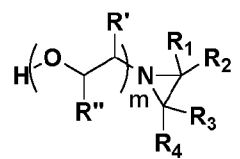
R₁₀ is an aliphatic hydrocarbon group containing from 1 to 20 carbon atoms (preferably CH₃), a cycloaliphatic hydrocarbon group containing from 5 to 20 carbon atoms or an aromatic hydrocarbon group containing from 6 to 20 carbon atoms.

15 12. The aqueous coating composition according to any one of the preceding claims, characterized in that structural units A are according to the following structural formula D:



20 wherein R', R'', m, R₁, R₂, R₃ and R₄ are defined as in any of the preceding claims.

13. The aqueous coating composition according to any of the preceding claims, characterized in that the multi-aziridine compound is obtained by reacting at least a polyisocyanate and a compound B with the following structural formula:



25

whereby the molar ratio of compound B to polyisocyanate is from 2 to 6, more preferably from 2 to 4 and most preferably from 2 to 3, and whereby m, R', R'', R₁, R₂, R₃ and R₄ are defined as in the preceding claims.

14. The aqueous coating composition according to claim 13, characterized in that
5 the polyisocyanate is a polyisocyanate with aliphatic reactivity in which all of the isocyanate groups are directly bonded to aliphatic or cycloaliphatic hydrocarbon groups, irrespective of whether aromatic hydrocarbon groups are also present.
15. The aqueous coating composition according to any of claims 12 to 14,
10 characterized in that the number of consecutive C atoms and optionally O atoms between the N atom of the urethane group in a structural unit D and the next N atom which is either present in the linking chain or which is the N atom of the urethane group of another structural unit D is at most 9.
16. The aqueous coating composition according to any of the preceding claims,
15 characterized in that the multi-aziridine compound has a molecular weight of from 600 to 5000 Daltons, more preferably the multi-aziridine compound has a molecular weight of at least 800 Daltons, even more preferably at least 840 Daltons, even more preferably at least 1000 Daltons and preferably at most 3800 Daltons, more preferably at most 3600 Daltons, more preferably at most 3000 Daltons, more preferably at most 1600 Daltons, even more preferably at
20 most 1400 Daltons.
17. The aqueous coating composition according to any of the preceding claims,
characterized in that the aqueous coating composition comprises aziridine
25 functional molecules having a molecular weight lower than 580 Daltons in an amount lower than 0.5 wt.%, on the total weight of the aqueous coating composition, whereby the molecular weight is determined using LC-MS as described in the description.
18. The aqueous coating composition according to any of the preceding claims,
30 characterized in that the pH of the aqueous coating composition is in the range from 9.5 to 11.5.
19. The aqueous coating composition according to any of the preceding claims,
characterized in that the amount of water in the aqueous coating composition
is at least 15 wt.%, preferably at least 20 wt.%, more preferably at least 30
wt.%, even more preferably at least 40 wt.%, on the total weight of the

- aqueous dispersion and at most 90 wt.%, preferably at most 85 wt.%, more preferably at most 80 wt.%, even more preferably at most 70 wt.%, even more preferably at most 60 wt.%, on the total weight of the aqueous coating composition.
- 5 20. The aqueous coating composition according to any of the preceding claims, characterized in that the amount of said multi-aziridine compound in the aqueous coating composition is at least 0.5 wt.%, more preferably at least 1 wt.%, more preferably at least 1.5 wt.%, more preferably at least 2 wt.%, even more preferably at least 3 wt.%, even more preferably at least 4 wt.%, even
10 more preferably at least 5 wt.%, even more preferably at least 7 wt.%, and at most 50 wt.%, more preferably at most 30 wt.%, even more preferably at most 20 wt.%, even more preferably at most 15 wt.% and even more preferably at most 12 wt.%, on the total solids content of the aqueous coating composition.
- 15 21. The aqueous coating composition according to any of the preceding claims, characterized in that the amounts of aziridinyl groups and of carboxylic acid groups and carboxylate groups are chosen such that the stoichiometric amount (SA) of aziridinyl groups on carboxylic acid groups and carboxylate groups is from 0.1 to 2.0, more preferably from 0.2 to 1.5, even more preferably from 0.25 to 0.95, most preferably from 0.3 to 0.8.
- 20 22. The aqueous coating composition according to any of the preceding claims, characterized in that the solids content of the aqueous coating composition is at least 5, preferably at least 10, even more preferably at least 20, even more preferably at least 25, even more preferably at least 35 and at most 55, more preferably at most 50 and even more preferably at most 45 wt.%.
- 25 23. The aqueous coating composition according to any of the preceding claims, characterized in that the particles X comprising said multi-aziridine compound have a scatter intensity based average hydrodynamic diameter from 30 to 500 nanometer, more preferably from 50 to 350 nm, even more preferably from 110 to 275 nm, wherein the scatter intensity based average hydrodynamic
30 diameter is determined as specified in the description.
- 35 24. The aqueous coating composition according to any of the preceding claims, characterized in that the particles Y comprising said carboxylic acid functional polymer have a scatter intensity based average hydrodynamic diameter from 30 to 30000 nanometer, more preferably from 40 to 10000 nm, even more preferably from 40 to 3000 nanometer, even more preferably from 40 to 500

nm, even more preferably from 60 to 260 nm, wherein the scatter intensity based average hydrodynamic diameter is determined as specified in the description.

25. The aqueous coating composition according to any of the preceding claims,
5 characterized in that the carboxylic acid functional polymer is selected from the group consisting of vinyl polymers, polyacrylates, polymethacrylates, poly(acrylate-co-methacrylate)s and mixtures thereof.
26. The aqueous coating composition according to any of claims 1- 24,
10 characterized in that the carboxylic acid functional polymer is selected from the group consisting of polyurethanes, poly(urethane-co-acrylate)s, poly(urethane-co-methacrylate)s, poly(urethane-co-acrylate-co-methacrylate), polyureas, and mixtures thereof.
27. The aqueous coating composition according to any of the preceding claims,
15 characterized in that the carboxylic acid functional polymer has an acid value of from 2 to 135 mg KOH/gram of the carboxylic acid functional polymer, more preferably from 3 to 70 mg KOH/g carboxylic acid functional polymer, even more preferably from 5 to 50 mg KOH/g carboxylic acid functional polymer and even more preferably from 10 to 25 mg KOH/g carboxylic acid functional polymer.
- 20 28. The aqueous coating composition according to any of the preceding claims, characterized in that the aqueous coating composition comprises a dispersant.
29. The aqueous coating composition according to any of the preceding claims,
25 characterized in that the aqueous coating composition comprises a separate surface-active molecule component as dispersant in an amount ranging from 0.1 to 20 wt.%, on the total weight of the aqueous coating composition.
30. The aqueous coating composition according to claim 29, characterized in that
30 the dispersant is a polymer having a number average molecular weight of at least 2000 Daltons, more preferably at least 2500 Daltons, more preferably at least 3000 Daltons, more preferably at least 3500 Daltons, more preferably at least 4000 Daltons, and preferably at most 1000000 Daltons, more preferably at most 100000, at most 10000 Daltons and the polymer is a polyether, more preferably a polyether copolymer, even more preferably a polyether block copolymer, even more preferably a poly(alkylene oxide) block copolymer,
35 even more preferably a poly(ethylene oxide)- co-poly(propylene oxide) block

copolymer, wherein the number average molecular weight is determined using MALDI-ToF mass spectrometry as described in the description.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/051379

A. CLASSIFICATION OF SUBJECT MATTER				
INV. C08G18/08	C08G18/10	C08G18/12	C08G18/28	C08G18/30
C08G18/32	C08G18/34	C08G18/48	C08G18/66	C08G18/73
C08G18/75	C08G18/79	C09D175/08	C08G18/02	C09D175/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols) C08G C09D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 523 750 A (TESORO GIULIANA C) 11 August 1970 (1970-08-11) column 5 - column 8 claim 4 column 10, lines 10-11 -----	1-30
X	US 5 258 481 A (HESSELMANS LAURENTIUS C J [NL] ET AL) 2 November 1993 (1993-11-02) column 15; example 5 column 13, line 54 - line 56 -----	1-9, 12-30 10,11
A	US 5 241 001 A (KANIA CHARLES M [US] ET AL) 31 August 1993 (1993-08-31) column 8; example 2 column 7, line 26 - line 30 claim 1 -----	1-10, 12-30 11

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 4 May 2021	Date of mailing of the international search report 18/05/2021
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Wohnhaas, Christian
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2021/051379

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