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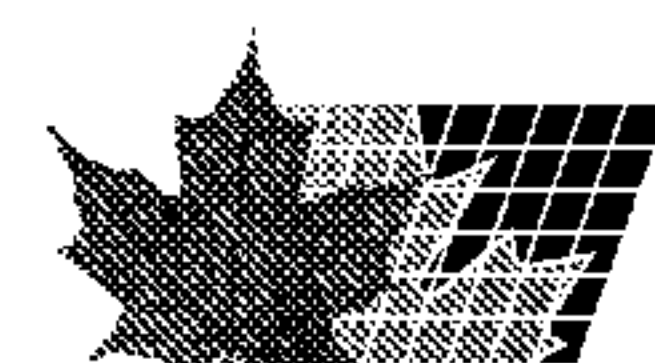
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(54) Titre : SYSTEMES A BASE DE DIMALEIDE DURCISSABLE

(54) Title: CURABLE BISMALÉIDE SYSTEMS

(57) Abrégé/Abstract:

There are disclosed novel compositions comprising a) at least one bismaleide, b) at least one mono- or polynuclear alkenylphenol, one alkenylphenol ether or a mixture thereof, wherein the alkenyl group contains at least three 3 carbon atoms, c) a copolyether resin. The compositions of the invention can be cured to products having improved toughness and high glass transition temperatures. These products are suitable for making high-performance moulded articles which can be subjected to high temperatures, for example fibre-reinforced composites, structural adhesives, laminating or electrical insulating resins.



K-18091/ANovel curable bismaleide systemsAbstract of the Disclosure

There are disclosed novel compositions comprising

- a) at least one bismaleide,
- b) at least one mono- or polynuclear alkenylphenol, one alkenylphenol ether or a mixture thereof, wherein the alkenyl group contains at least three 3 carbon atoms,
- c) a copolyether resin.

The compositions of the invention can be cured to products having improved toughness and high glass transition temperatures. These products are suitable for making high-performance moulded articles which can be subjected to high temperatures, for example fibre-reinforced composites, structural adhesives, laminating or electrical insulating resins.

K-18091/A

Novel curable bismaleide systems

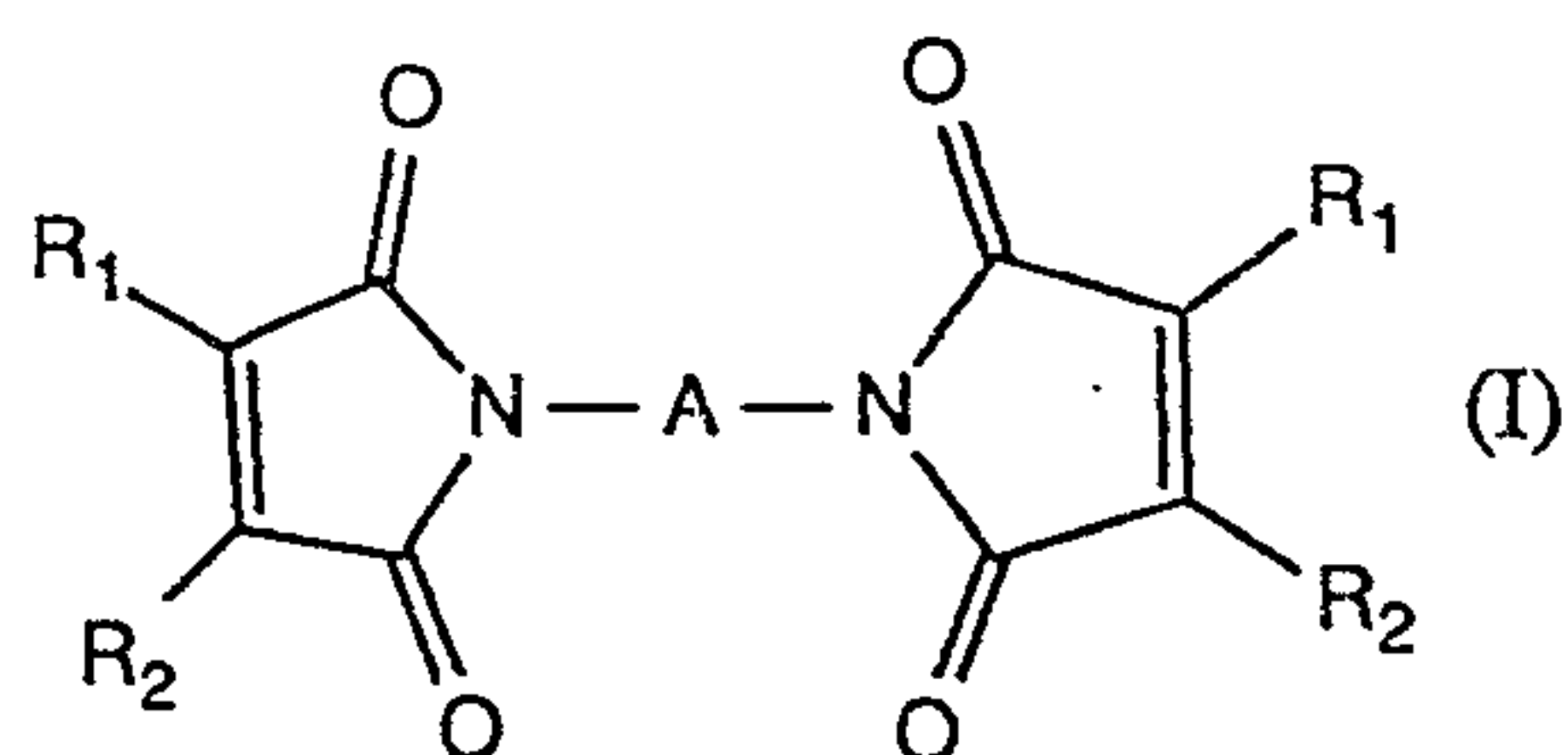
The present invention relates to compositions comprising bismaleides, an alkenylphenol and/or an alkenylphenol ether and a copolyether resin, as well as a process for making cured products using the compositions of the invention.

A process for the preparation of crosslinked polymers containing imide groups by reacting polymaleimides and alkenylphenols and/or alkenylphenol ethers is disclosed in US patent specification 4 100 140. Curable compositions of propenyl-substituted copolyether resins and bismaleimides (BMI) are disclosed in EP-A 327 498, which compositions may be used and processed in the conventional manner for thermoplastics and exhibit the characteristic properties of thermoset plastics after curing, for example high strength and glass transition temperature.

It is the object of this invention to provide BMI systems which have greater toughness and high glass transition temperatures and which can be processed and cured at relatively low temperatures.

Specifically, the invention relates to compositions comprising

a) at least one bismaleimide of formula I



wherein R_1 and R_2 are each independently of the other hydrogen or methyl and A is a divalent organic radical of 2 to 30 carbon atoms,

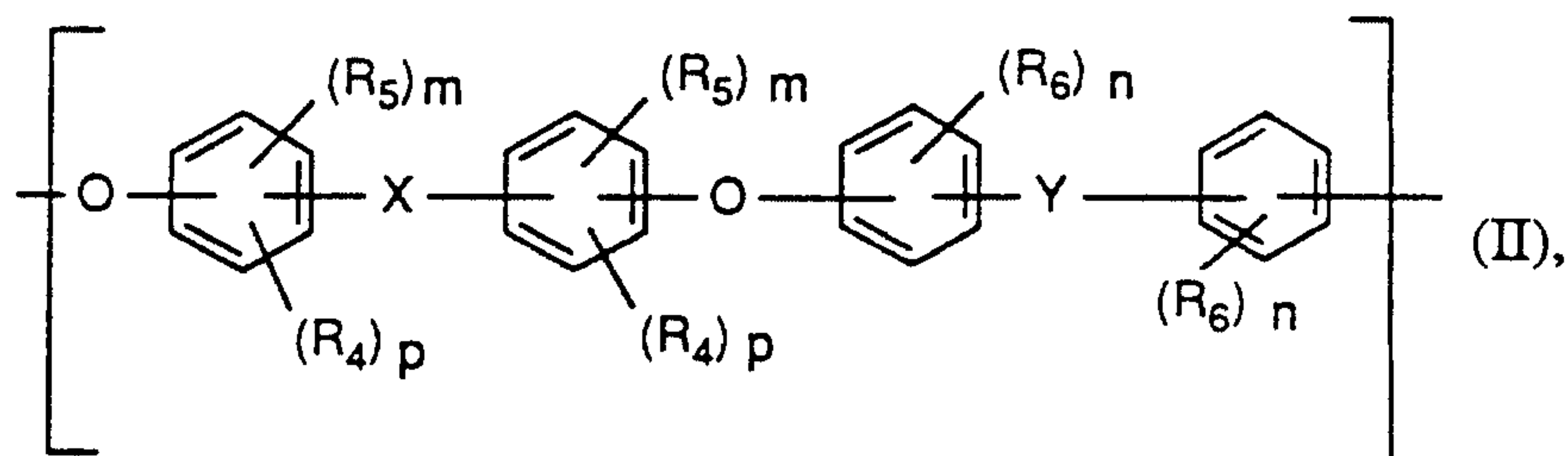
b) at least one mononuclear or polynuclear alkenylphenol, an alkenylphenol ether or a mixture thereof, wherein the alkenyl group contains at least three carbon atoms,

c) a copolyether resin containing end groups -OR_3 attached direct to phenyl nuclei and 1 to

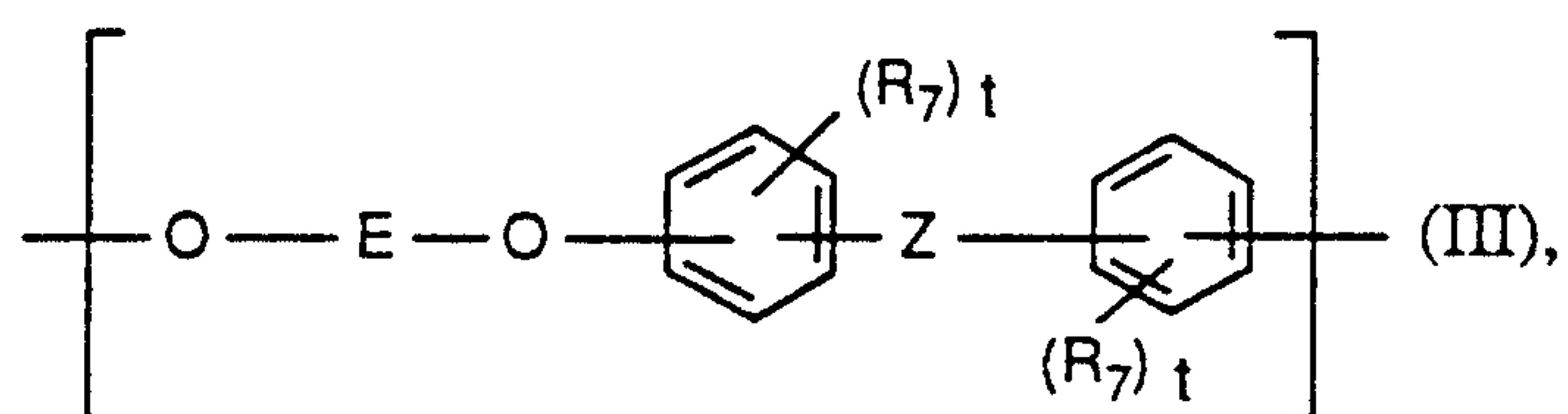
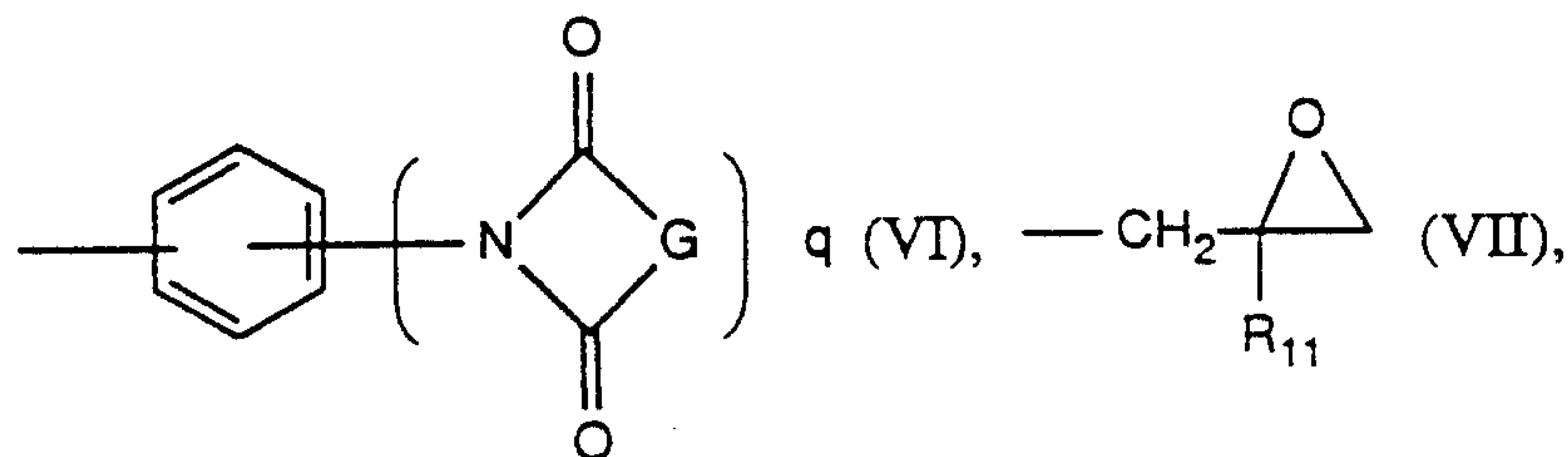
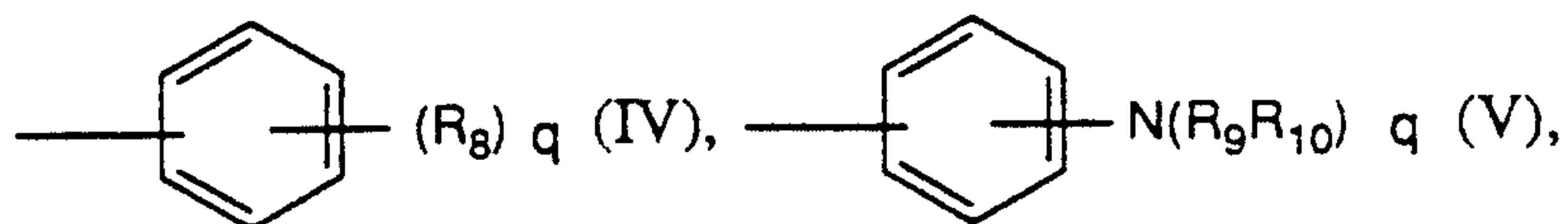
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50 mol % of structural repeating units of formula II



and 50 to 99 mol % of structural repeating units of formula III

wherein R_3 is hydrogen or a radical of formulae IV to VII

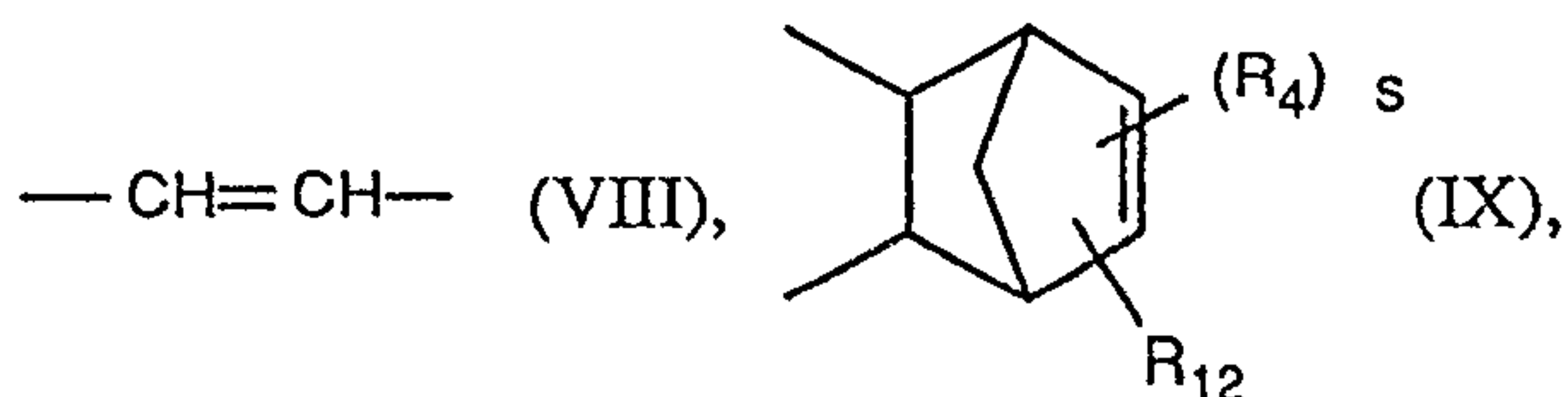
X is a direct bond or a group of formulae $-\text{C}_r\text{H}_{2r}-$, $-\text{CH}(\text{C}_6\text{H}_5)-$,
 20 $-\text{C}(\text{CF}_3)_2-$, $-\text{S}-$, $-\text{SO}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, r is 1 to 20, R_4 is
 prop-1-enyl or 2-methylprop-1-enyl, R_5 , R_6 and R_7 are each
 independently of one another C_1 - C_4 alkyl, C_1 - C_4 alkoxy or chloro or
 bromo, m, n and t are each independently of one another 0, 1 or

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2a

2, p is 1 or 2, E is a divalent radical of a bisphenol after removal of both phenolic hydroxyl groups, which radical is unsubstituted or substituted by one or two C₁-C₄alkyl or C₁-C₄alkoxy groups or one or two chlorine or bromine atoms, Y and Z are each independently of the other -CO- or -SO₂-, R₈ is vinyl, ethynyl, allyl, methallyl, prop-1-enyl or 2-methylprop-1-enyl, R₉ and R₁₀ are each independently of the other hydrogen, allyl or methallyl, R₁₁ is hydrogen or methyl, q is 1 or 2, G is a group of formulae VIII or IX,

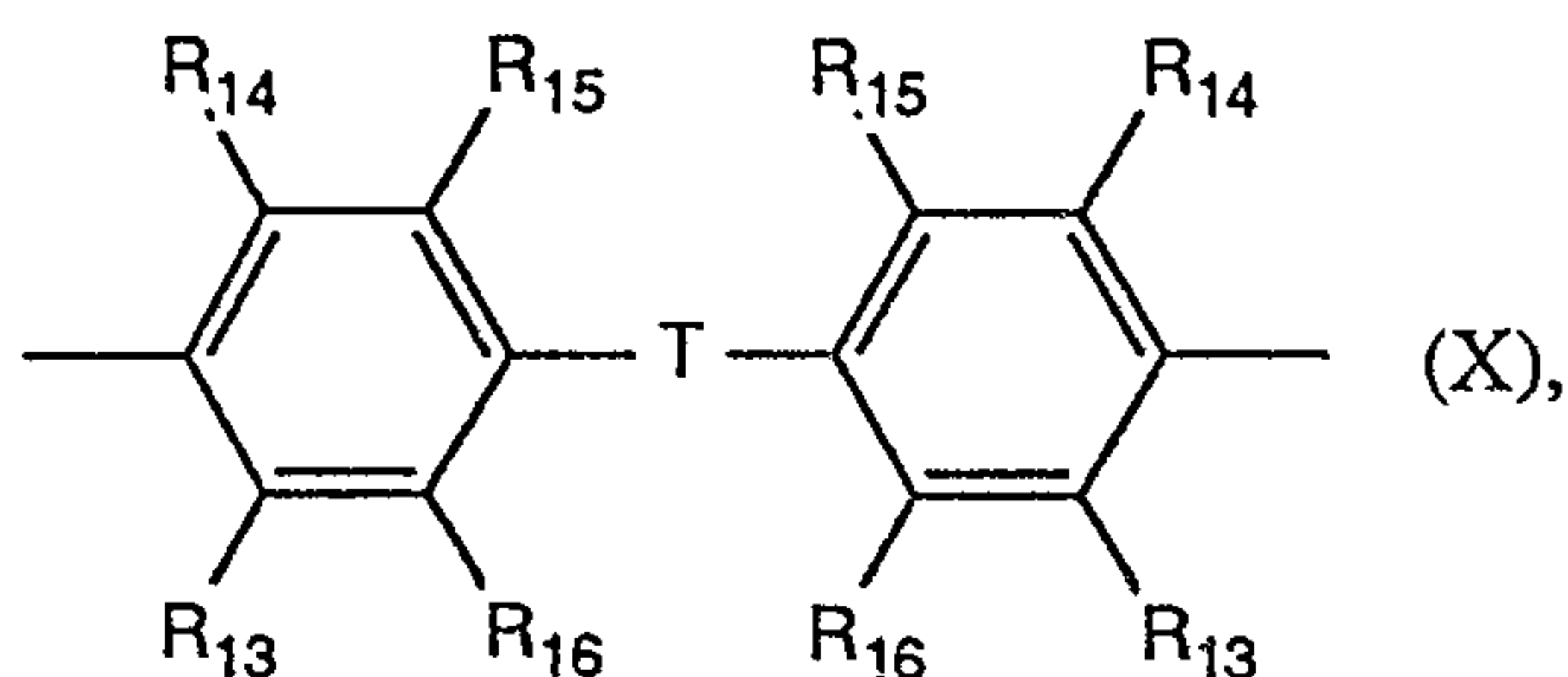
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wherein R_{12} is hydrogen or methyl and s is 0, 1 or 2.

The bismaleimides of formula I are known compounds and are described, for example, in US patent specification 4 100 140. They are preferably compounds of formula I, wherein R_1 and R_2 are hydrogen.

Preferred bismaleides are compounds of formula I, wherein A is $\text{-C}_2\text{H}_{2u}\text{-}$, in which u is 2-20, phenylene, xylylene, naphthylene, cyclopentylene, 1,5,5-trimethylcyclohexyl-1,3-ene; cyclohexyl-1,4-ene; 1,4-bis(methylene)cyclohexylene, the radical of 4,4'-bis(cyclohexyl)methane or a group of formula X,



wherein R_{13} and R_{14} are identical or different and are each hydrogen or $\text{C}_1\text{-C}_4$ alkyl, R_{15} and R_{16} are each independently of the other a hydrogen or halogen atom, and T is a direct bond, methylene, 2,2-propylidene, -S- , -SO- , $\text{-SO}_2\text{-}$, -O- or -CO- .

Particularly preferred compounds of formula I are those wherein A is a group of formula X, wherein R_{13} and R_{14} are each independently of the other hydrogen, methyl or ethyl, R_{15} and R_{16} are hydrogen and T is methylene.

Methylenebis(phenylmaleimide) is most especially preferred.

Mixtures of two or more different bismaleimides may of course also be used.

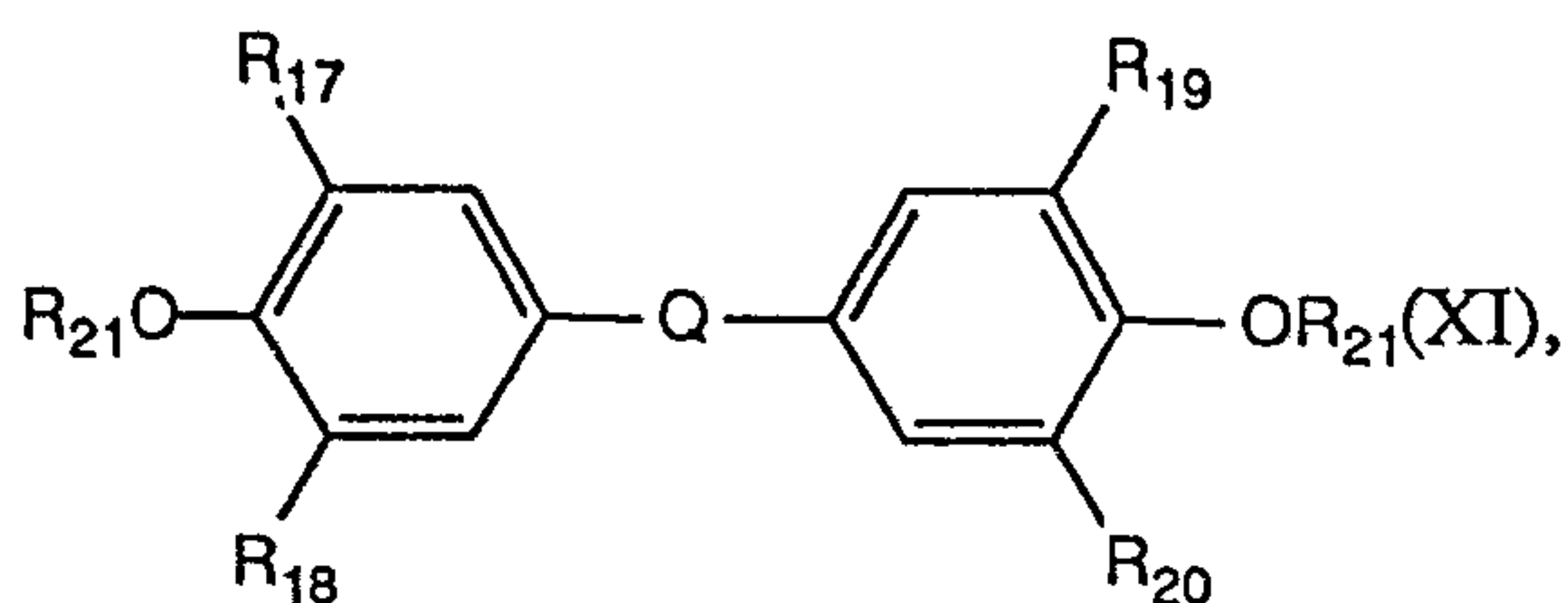
Representative examples of bismaleimides of formula I are: N,N'-ethylenebismaleimide, N,N'-hexamethylenebismaleimide, N,N'-trimethylhexylenebismaleimide, N,N'-m-pheny-

lenebismaleimide, N,N'-4,4'-diphenylmethanebismaleimide, N,N'-4,4'-diphenyl ether bismaleimide, N,N'-(1,5,5-trimethylcyclohexyl-1,3-ene)bismaleimide, N,N'-4,4'-dicyclohexylmethanebismaleimide, N,N'-p-xylylenebismaleimide, N,N'-4,4'-bis(2-ethyl-6-methylphenyl)methanebismaleimide, N,N'-4,4'-bis(2,6-dimethylphenyl)methanebismaleimide, N,N'-4,4'-bis(2,6-diethylphenyl)methanebismaleimide, N,N'-4,4'-bis(2,6-diisopropylphenyl)methanebismaleimide, N,N'-4,4'-bis(2-ethyl-6-isopropylphenyl)methanebismaleimide, N,N'-4,4'-bis(3-chloro-2,6-diethylphenyl)methanebismaleimide.

The compounds of formula I are prepared by known methods, for example by reacting the unsubstituted or substituted maleic anhydride with the corresponding diamines.

Conventional methods are described in US patent specification 3 010 290 or in GB patent specification 1 137 592.

Alkenylphenols or alkenylphenol ethers are known compounds and are described, for example, in US patent specification 4 100 140. Preferred compounds are those of formula XI



wherein Q is a direct bond, $-\text{CH}_2-$, $-\text{C}(\text{CH}_3)_2-$, $-\text{S}-$, $-\text{SO}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, R_{17} , R_{18} , R_{19} and R_{20} are each independently of one another hydrogen or C_3 - C_{10} alkenyl, and at least one of R_{17} to R_{20} is an alkenyl group, and R_{21} is hydrogen, C_1 - C_{10} alkyl, C_6 - C_{10} aryl or C_3 - C_{10} alkenyl.

The alkenyl group in compounds of formula XI is preferably an allyl, methallyl or propenyl group.

In the compositions of this invention it is preferred to use compounds of formula XI, wherein Q is $-\text{CH}_2-$, $-\text{C}(\text{CH}_3)_2-$, $-\text{S}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, R_{17} and R_{19} are each allyl, R_{18} and R_{20} are each hydrogen and R_{21} is hydrogen.

Particularly preferred alkenylphenols of formula XI are those wherein Q is $-\text{C}(\text{CH}_3)_2-$, R_{17} and R_{19} are each allyl, R_{18} and R_{20} are each hydrogen, and R_{21} is hydrogen.

It is preferred to use compounds of formula XI which contain two alkenyl groups in each molecule.

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Typical examples of alkenylphenols or alkenylphenol ethers which may be used in the compositions of this invention are:

o,o'-diallyl bisphenol A,
o,o'-diallyl bisphenol F,
4,4'-dihydroxy-3,3'-diallyldiphenyl,
4,4'-diallyloxydiphenyl.

The corresponding methallyl compounds can also be used.

Alkenylphenols are obtained by (thermal) Claisen rearrangement of the alkenyl ethers of phenols (q.v. USP 4 100 140). The alkenyl ethers are also obtained by known methods, for example by reacting phenols with allyl chloride in the presence of an alkali metal hydroxide.

It is also possible to use mixtures of compounds which contain only one hydroxyl group and only one alkenyl group in the aromatic nucleus with compounds which contain several hydroxyl groups and/or several alkenyl groups in the aromatic nucleus, or mixtures of the corresponding phenyl ethers of these compounds.

The alkenyl-substituted copolyether resins containing structural repeating units of formulae II and III are disclosed in EP-A 327 498.

In the compositions of the invention it is preferred to use polyether sulfones/ketones containing structural repeating units of formulae II and III, wherein the indices m, n and t are 0 and p and q are 1.

R₃ is preferably hydrogen or a radical of formula V, wherein R₉ and R₁₀ are each hydrogen and q is 1.

The preferred meaning of X in formula II is a direct bond, -CH₂-, -CH(CH₃)-, -CH(C₆H₅)-, -C(CH₃)₂-, -C(CF₃)₂-, -S-, -SO-, -SO₂-, -O- or -CO-.

Most preferably X is a direct bond, -CH₂- or -C(CH₃)₂-.

The preferred meaning of R₄ is prop-1-enyl.

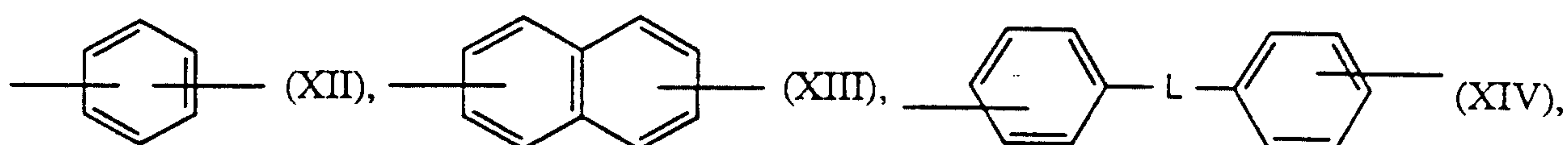
The substituents R₄ in formula II are preferably each in ortho-position to the phenolic -O- atom.

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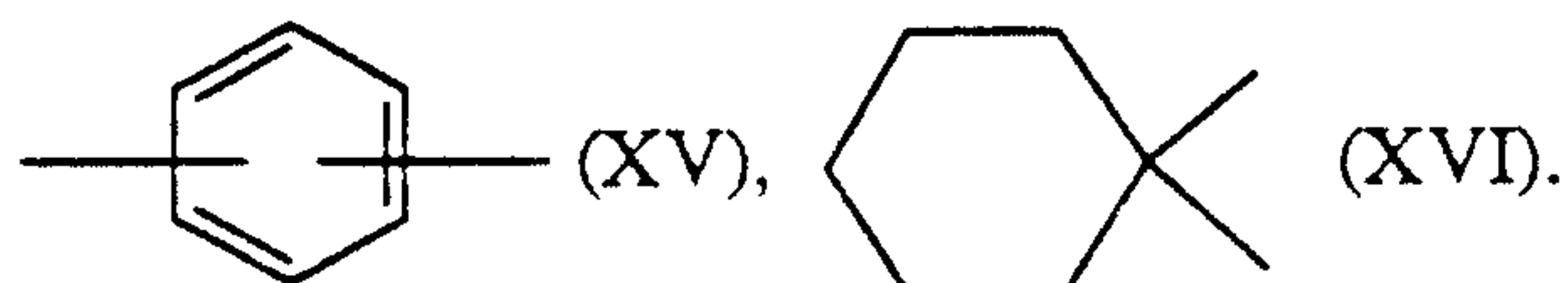
The group E as divalent radical of a bisphenol is normally the divalent radical of a mono- or polynuclear carbocyclic-aromatic phenol, preferably the radical of a mono- or binuclear carbocyclic-aromatic phenol, both aromatic nuclei
 5 of which are fused or linked to each other through a linking group.

Preferred radicals E have the formulae XII to XIV



wherein L is a direct bond, a group of formulae $-C_rH_{2r}-$ ($r=1$ to 20), $-CH(C_6H_5)-$, $-C(CF_3)_2-$, $-S-$, $-SO_2-$, $-O-$ or $-CO-$, or is a group of formula XV or XVI

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Most particularly preferred radicals E have the formulae XII, XIII or XIV, wherein L is a direct bond or a group of formula $-CH_2-$, $-CH(CH_3)-$, $-CH(C_2H_5)-$, $-C(CH_3)(C_2H_5)-$,
 20 $-C(CF_3)_2-$, $-S-$, $-SO_2-$ or $-CO-$.

Y and Z preferably have the same meaning.

Especially preferred components c) are copolyether resins comprising 2 to 30 mol % of structural repeating units of formula II and 98 to 70 mol % of structural repeating units
 25 of formula III and having an average molecular weight (number average) of 2,000 to 30,000, preferably 5,000 to 20,000.

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The compositions of this invention preferably contain 5-100 % by weight, most preferably 10-50 % by weight of component c), based on the amount of component a).

The molar ratio of component b):a) is preferably
5 (0.5-1.4):1, preferably (0.7-1.2):1.

The compositions of the invention are cured in known manner, typically in the temperature range from 100 to 300°C for a time sufficient to effect the cure.

The expression "cure" as used herein means the
10 conversion of low viscosity resin compositions into insoluble and infusible crosslinked products. It is thus possible to prepare high-performance

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moulded articles such as (fibre-reinforced) composites, structural adhesives, laminating or electrical insulating resins which can be subjected to high temperatures.

The compositions of the invention can be mixed at any stage prior to the cure with conventional modifiers such as extenders, fillers and reinforcing agents, pigments, dyes, organic solvents, plasticisers, tackifiers, tougheners, rubbers, accelerators, flame retardants or thixotropic agents. Illustrative examples of suitable modifiers are: coal tar, bitumen, glass fibres, boron fibres, carbon fibres, cellulose, polyethylene powder, polypropylene powder, mica, asbestos, quartz powder, gypsum, antimony trioxide, bentones, silica aerogel ("aerosil"), lithopone, barites, titanium dioxide, carbon black, graphite, iron oxide, metal powders such as aluminium powder or iron powder, silicones, cellulose acetate butyrate, polyvinyl butyrate, waxes and stearates.

Suitable additional tougheners are products which are known to the skilled person, such as polyimides (for example Matrimid[®] 5218, Ciba-Geigy), polyether imides (for example Ultem[®] 1000, General Electric), polyether sulfones or ketones (for example Victrex[®], ICI or Ultrason[®] E, BASF) or polyhydantoins.

The compositions of the invention are very readily processible, have good solubility in customary organic solvents, good stability in the melt or in solution, and the cured products made from them have good thermal and mechanical properties. The products obtained have enhanced toughness and high glass transition temperatures.

The invention accordingly also relates to a process for the preparation of cured products, which comprises the use of the novel compositions.

The compositions of this invention can be used in different fields, for example in prepregs, laminates, composites, printed circuit boards, castings, mouldings, adhesives and coatings. A particularly interesting utility is the fabrication of fibre-reinforced composites.

Example 1

In a round flask, 75 g of o,o'-diallyl bisphenol A is heated to 150°C and, with stirring, 10 g of a copolyether resin prepared according to Example 1 of EP-A 327 498 are added. When the resin has completely dissolved (15 min), 100 g of methylenebisphenylmaleimide are added, with stirring. The mixture is then stirred for a further 15 minutes at 125-130°C, degassed under a water jet vacuum, and poured into an aluminium mould (4 mm) of 180°C. The mixture is fully cured for 1 h at 180°C, for 2 h at 200°C and, finally, for 6 h at 250°C. The cured product has the following

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properties:

$T_{g \text{ onset}}$:	291°C
T_g :	301°C
flexural strength (according to ISO 178):	144 MPa
flexural elongation (according to ISO 178):	4.6 %

($T_{g \text{ onset}}$ is the point of intersection of the extended base line with the tangent at the calibration curve in the area of the steepest ascent (measured by TMA, using a Mettler TA 3000)).

Example 2: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 20 g of a copolyether resin prepared according to Example 1 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

$T_{g \text{ onset}}$:	286°C
T_g :	296°C
flexural strength (according to ISO 178):	148 MPa
flexural elongation (according to ISO 178):	5.0 %

Example 3: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 30 g of a copolyether resin prepared according to Example 1 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

$T_{g \text{ onset}}$:	282°C
T_g :	292°C
flexural strength (according to ISO 178):	161 MPa
flexural elongation (according to ISO 178):	5.5 %

Example 4: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 10 g of a copolyether resin prepared according to Example 2 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	299°C
T _g :	310°C
flexural strength (according to ISO 178):	107 MPa
flexural elongation (according to ISO 178):	3.6 %

Example 5: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 20 g of a copolyether resin, prepared according to Example 2 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	300°C
T _g :	310°C
flexural strength (according to ISO 178):	159 MPa
flexural elongation (according to ISO 178):	5.5 %

Example 6: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 30 g of a copolyether resin, prepared according to Example 2 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	305°C
T _g :	312°C
flexural strength (according to ISO 178):	157 MPa
flexural elongation (according to ISO 178):	5.6 %

Example 7: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 10 g of a copolyether resin, prepared according to Example 5 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	304°C
T _g :	312°C
flexural strength (according to	

ISO 178):	162 MPa
flexural elongation (according to	
ISO 178):	5.8 %

Example 8: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 20 g of a copolyether resin, prepared according to Example 5 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	305°C
T _g :	313°C
flexural strength (according to	
ISO 178):	165 MPa
flexural elongation (according to	
ISO 178):	5.9 %

Example 9: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 30 g of a copolyether resin, prepared according to Example 5 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	305°C
T _g :	312°C
flexural strength (according to	
ISO 178):	167 MPa
flexural elongation (according to	
ISO 178):	6.6 %

Example 10: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 50 g of a copolyether resin, prepared according to Example 5 of EP-A 327 498, and 100 g of methylenebisphenylmaleimide. The product has the following properties:

T _{g onset} :	314°C
T _g :	326°C
flexural strength (according to	
ISO 178):	170 MPa
flexural elongation (according to	
ISO 178):	5.7 %

Example 11: In accordance with the general procedure described in Example 1, a cured product is prepared from 75 g of o,o'-diallyl bisphenol A, 50 g of a copolyether resin, prepared according to Example 5 of EP-A 327 498, and 50 g of methylenebisphenylmaleimide. The product has the following properties:

$T_{g \text{ onset}}$:	300°C
T_g :	308°C
flexural strength (according to ISO 178):	160 MPa
flexural elongation (according to ISO 178):	6.0 %

Example 12: 20 g of a copolyether resin, prepared according to Example 5 of EP-A 327 498, are dissolved, with stirring, over 30 minutes at 150°C in 44 g of o,o'-diallyl bisphenol A, and a mixture of 50 g of methylenebisphenylmaleimide and 50 g of methylenebis(2-ethyl-6-methyl-phenyl)maleimide is added. The reaction mixture is stirred for a further 15 minutes at 100°C, then degassed under vacuum (10 torr) and poured into a hot aluminium mould (4 mm) of 200°C. The mixture is fully cured for 1 h at 200°C, for 2 h at 220°C and, finally, for 6 h at 280°C. The product has the following properties:

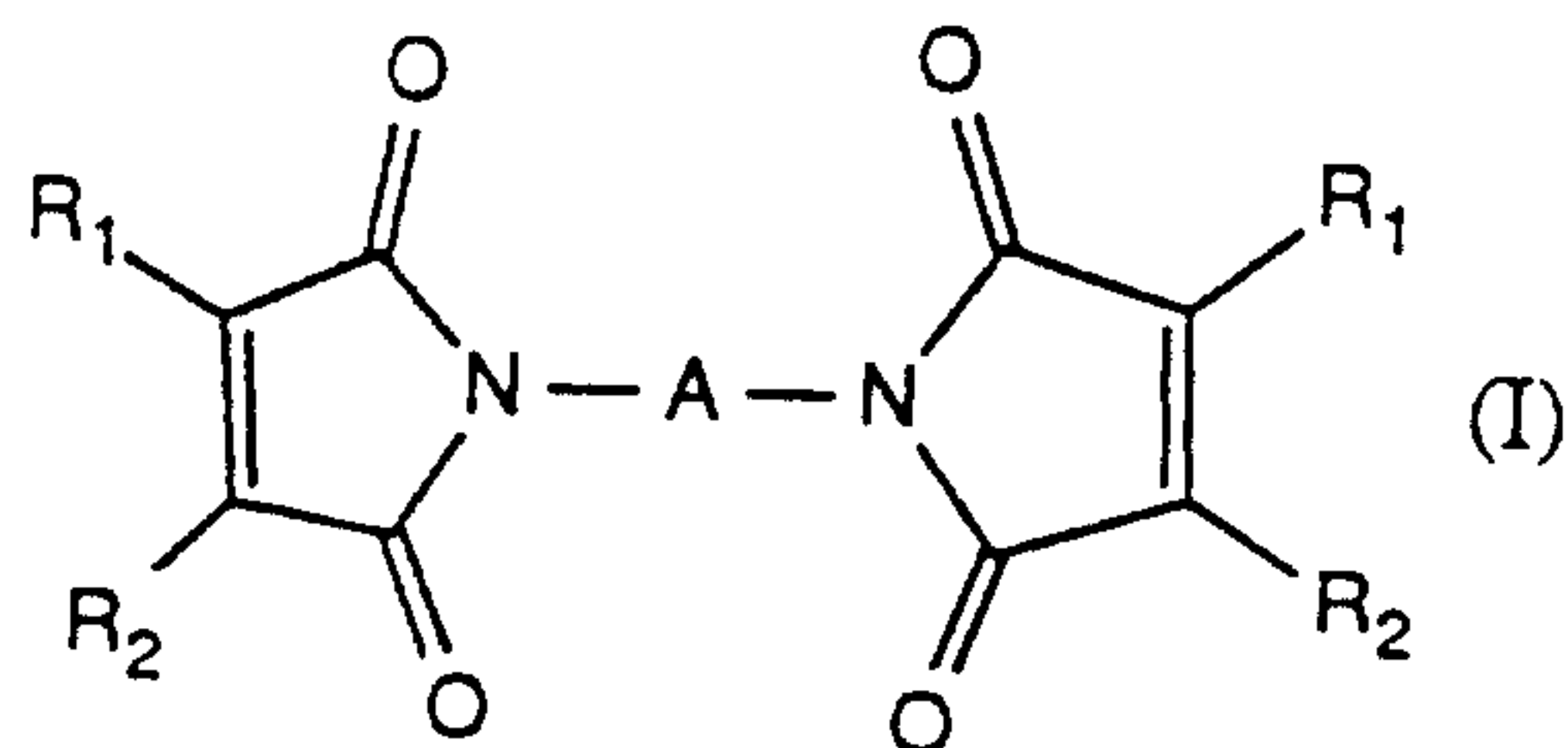
$T_{g \text{ onset}}$:	322°C
T_g :	331°C
flexural strength (according to ISO 178):	151 MPa
flexural elongation (according to ISO 178):	6.2 %

CLAIMS:

1. A composition comprising

a) at least one bismaleimide of formula I

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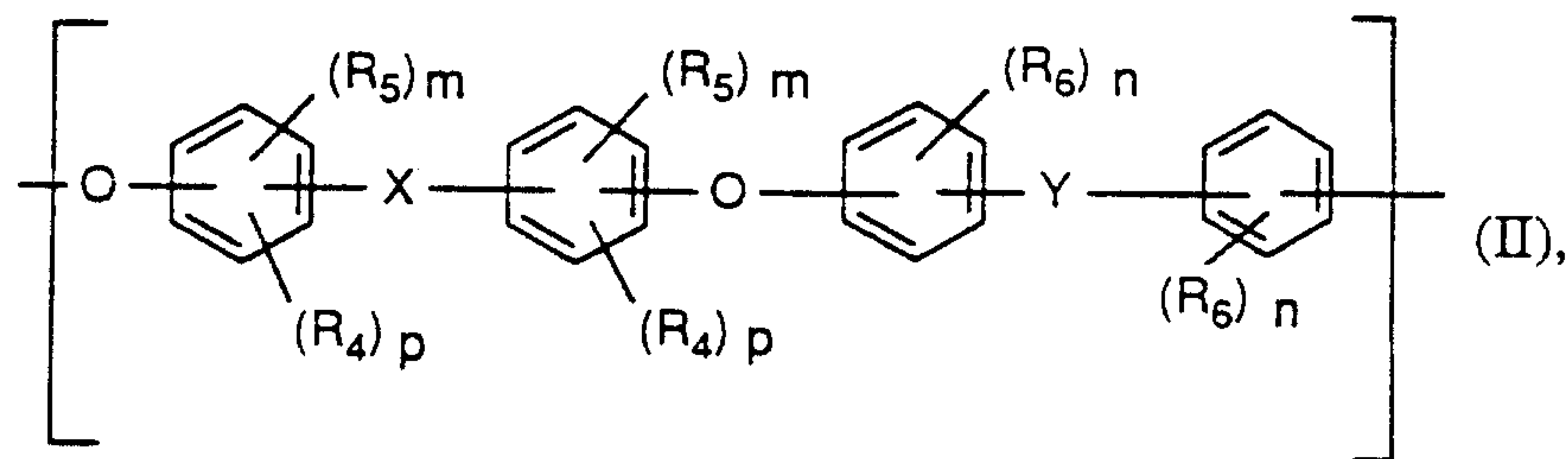
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wherein R_1 and R_2 are each independently of the other hydrogen or methyl and A is a divalent organic radical of 2 to 30 carbon atoms,

b) at least one mononuclear or polynuclear alkenylphenol, an alkenylphenol ether or a mixture thereof, wherein the alkenyl group contains at least three carbon atoms,

c) a copolyether resin containing end groups $-OR_3$ attached direct to phenyl nucleic and 1 to 50 mol % of structural repeating units of formula II

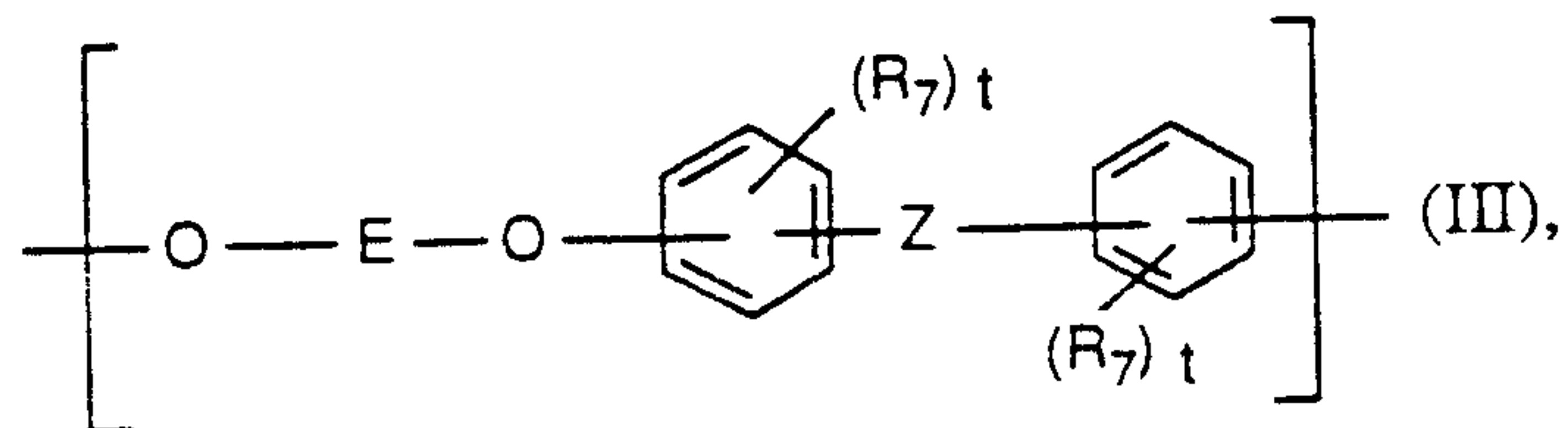
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and 50 to 99 mol % of structural repeating units of formula III

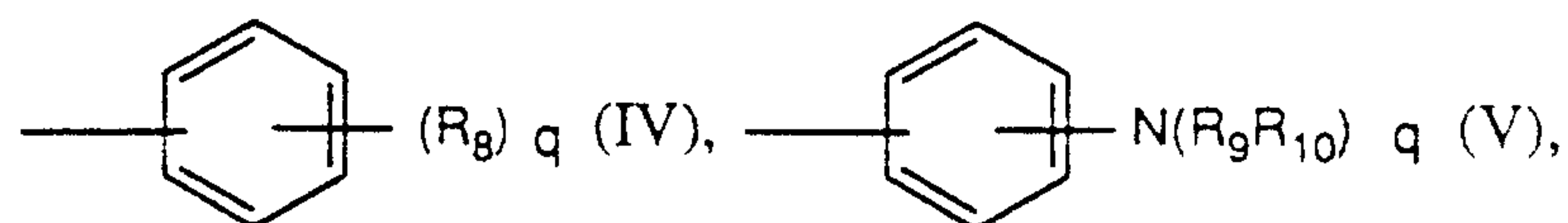
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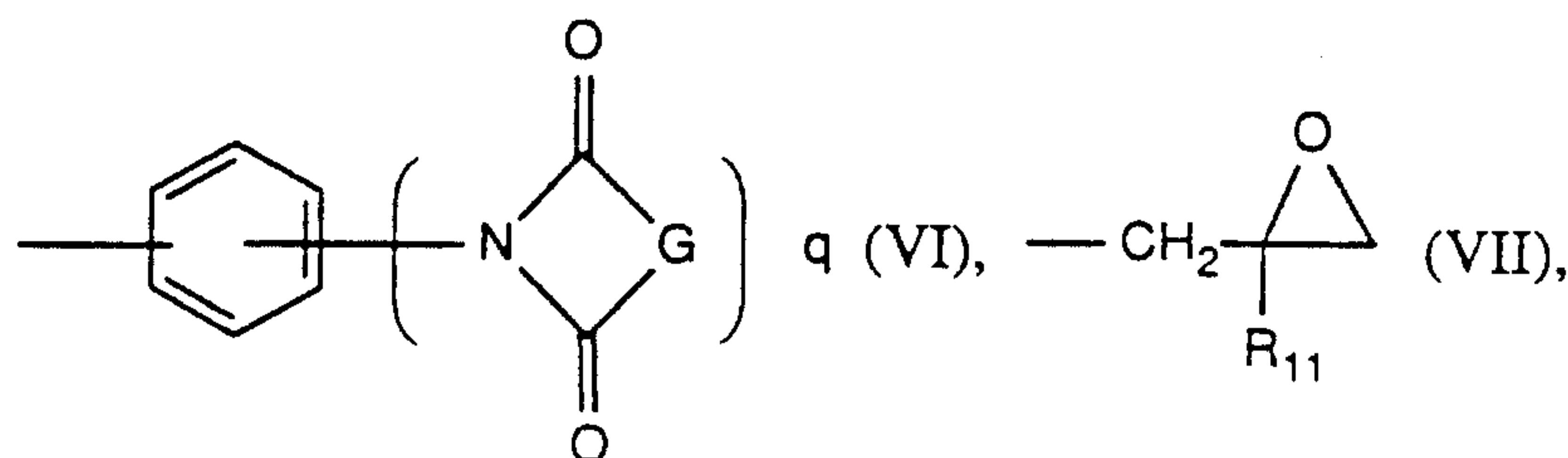


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wherein R_3 is hydrogen or a radical of formulae IV to VII



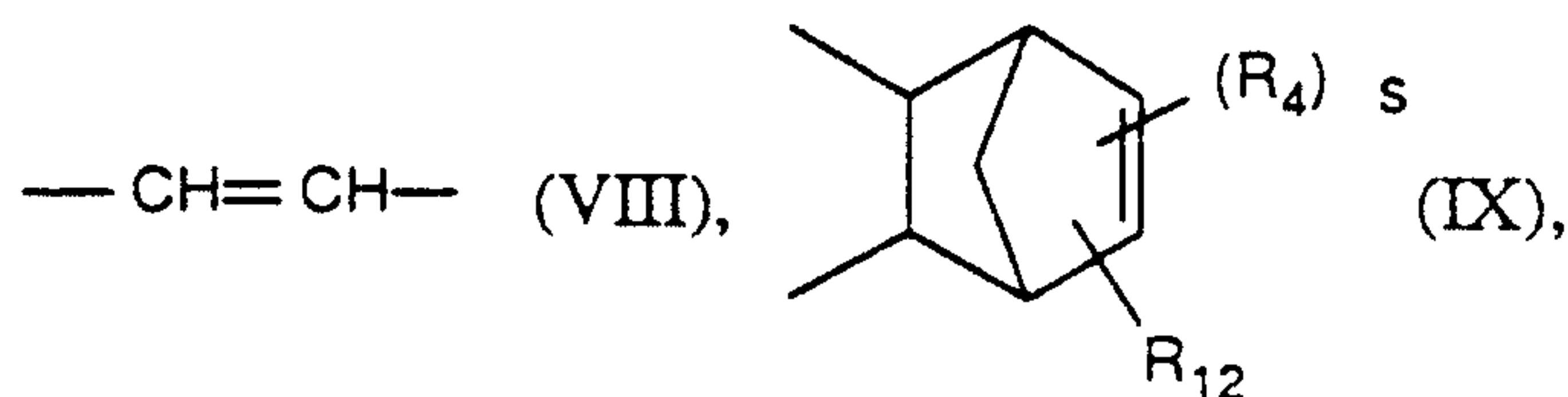
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X is a direct bond or a group of formulae $-\text{C}_r\text{H}_{2r}-$, $-\text{CH}(\text{C}_6\text{H}_5)-$, $-\text{C}(\text{CF}_3)_2-$, $-\text{S}-$, $-\text{SO}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, r is 1 to 20, R_4 is prop-1-enyl or 2-methylprop-1-enyl, R_5 , R_6 and R_7 are each independently of one another C_1 - C_4 alkyl, C_1 - C_4 alkoxy or chloro or bromo, m , n and t are each independently of one another 0, 1 or 2, p is 1 or 2. E is a divalent radical of a bisphenol after removal of both phenolic hydroxyl groups, which radical is unsubstituted or substituted by one or two C_1 - C_4 alkyl or C_1 - C_4 alkoxy groups or one or two chlorine or bromine atoms, Y and Z are each independently of the other $-\text{CO}-$ or $-\text{SO}_2-$, R_8 is vinyl, ethynyl, allyl, methallyl, prop-1-enyl or 2-methylprop-1-enyl, R_9 and R_{10} are each independently of the other hydrogen, allyl or methallyl, R_{11} is hydrogen or methyl, q is 1 or 2, G is a group of formulae VIII or IX,

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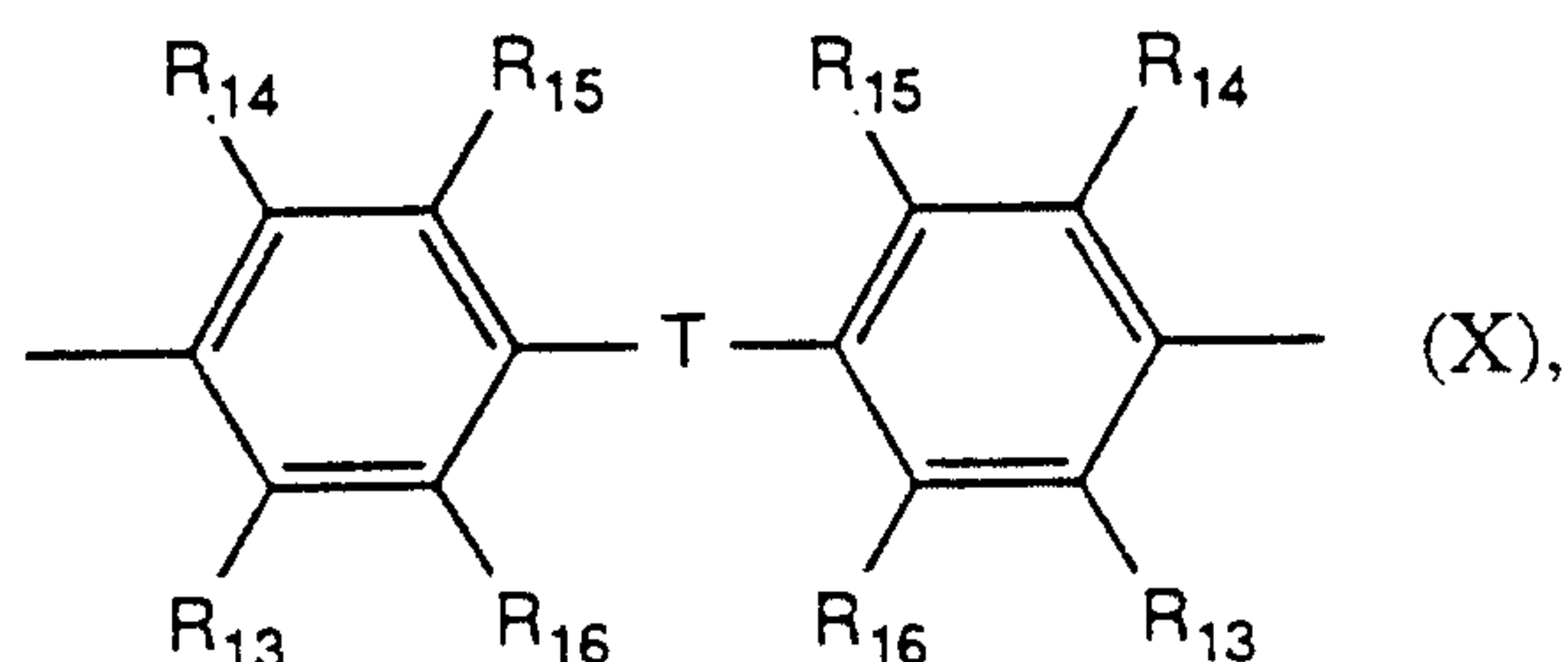


5 wherein R_{12} is hydrogen or methyl and s is 0, 1 or 2.

2. A composition according to claim 1, wherein R_1 and R_2 are hydrogen.

3. A composition according to claim 1 or 2 containing a compound of formula I, wherein A is $-C_2H_{2u}-$, in which u is 2-20,
 10 phenylene, xylylene, naphthylene, cyclopentylene, 1,5,5-trimethylcyclohexyl-1,3-ene; cyclohexyl-1,4-ene; 1,4-bis(methylene)cyclohexylene, the radical of 4,4'-bis(cyclohexyl)methane or a group of formula X,

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wherein R_{13} and R_{14} are identical or different and are each hydrogen or C_1-C_4 alkyl, R_{15} and R_{16} are each independently of the
 20 other a hydrogen or halogen atom, and T is a direct bond, methylene, 2,2-propylidene, $-S-$, $-SO-$, $-SO_2-$, $-O-$ or $-CO-$.

4. A composition according to claim 3, wherein A is a group of formula X, wherein R_{13} and R_{14} are each independently of the other hydrogen, methyl or ethyl, R_{15} and R_{16} are hydrogen and
 25 T is methylene.

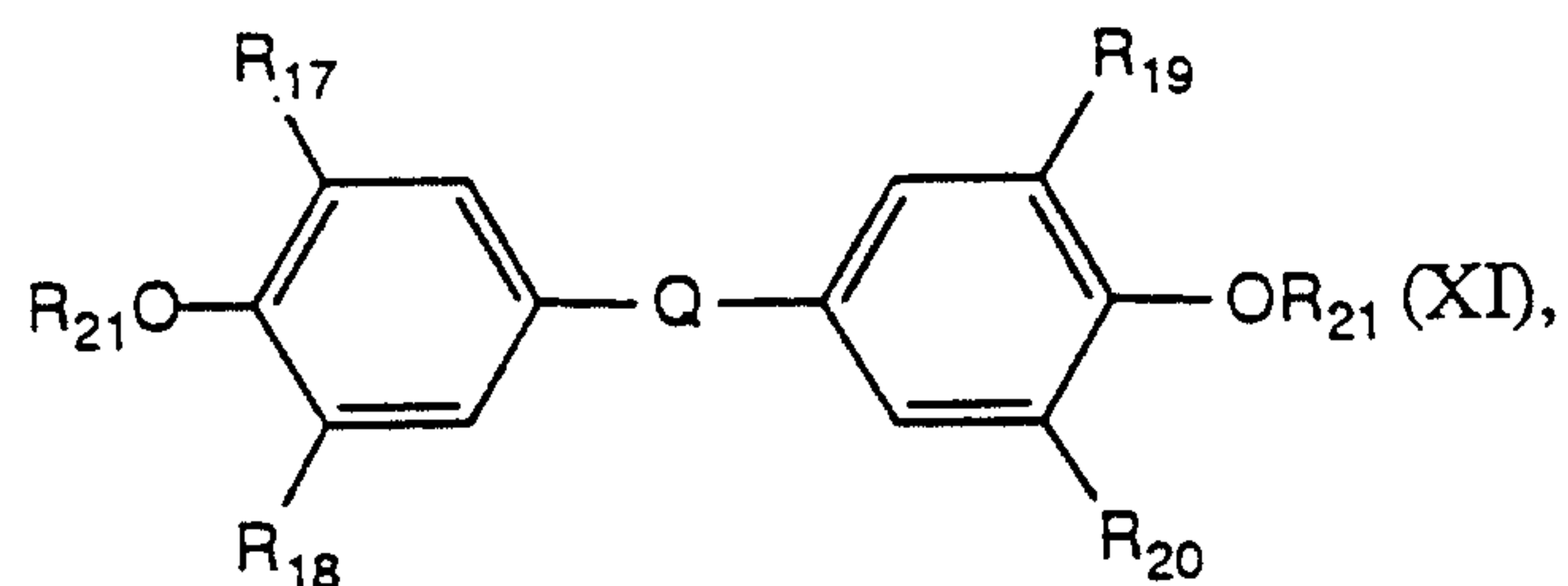
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5. A composition according to claim 1, wherein the compound of formula I is methylenebis(phenylmaleimide).

6. A composition according to any one of claims 1 to 5, wherein component b) is a compound of formula XI

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wherein Q is a direct bond, $-\text{CH}_2-$, $-\text{C}(\text{CH}_3)_2-$, $-\text{S}-$, $-\text{SO}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, R_{17} , R_{18} , R_{19} and R_{20} are each independently of one another hydrogen or C_3 - C_{10} alkenyl, and at least one of R_{17} to R_{20} is an alkenyl group, and R_{21} is hydrogen, C_1 - C_{10} alkyl, C_6 - C_{10} aryl or C_3 - C_{10} alkenyl.

7. A composition according to claim 6, wherein the alkenyl group in formula XI is an allyl, methallyl or propenyl group.

8. A composition according to claim 6, wherein Q is $-\text{CH}_2-$, $-\text{C}(\text{CH}_3)_2-$, $-\text{S}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, R_{17} and R_{19} are each allyl, R_{18} and R_{20} are each hydrogen and R_{21} is hydrogen.

9. A composition according to claim 6, wherein Q is $-\text{C}(\text{CH}_3)_2-$, R_{17} and R_{19} are each allyl, R_{18} and R_{20} are each hydrogen, and R_{21} is hydrogen.

10. A composition according to claim 1, wherein the indices m, n and t are 0, and p and q are 1.

11. A composition according to any one of claims 1 to 10, wherein R_3 is hydrogen or a radical of formula V, wherein R_9 and R_{10} are each hydrogen and q is 1.

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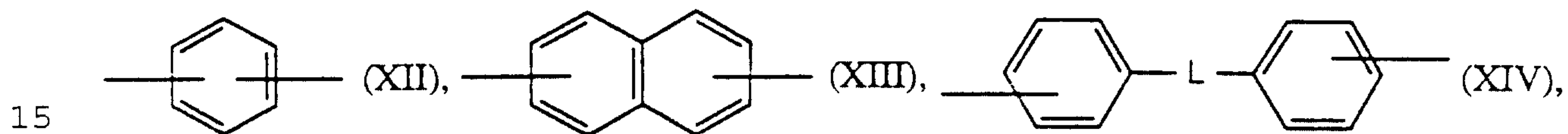
12. A composition according to any one of claims 1 to 11, wherein X is a direct bond, $-\text{CH}_2-$, $-\text{CH}(\text{CH}_3)-$, $-\text{CH}(\text{C}_6\text{H}_5)-$, $-\text{C}(\text{CH}_3)_2-$, $-\text{C}(\text{CF}_3)_2-$, $-\text{S}-$, $-\text{SO}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$.

13. A composition according to any one of claims 1 to 11, wherein X is a direct bond, $-\text{CH}_2-$ or $-\text{C}(\text{CH}_3)_2-$.

14. A composition according to any one of claims 1 to 13, wherein R_4 is prop-1-enyl.

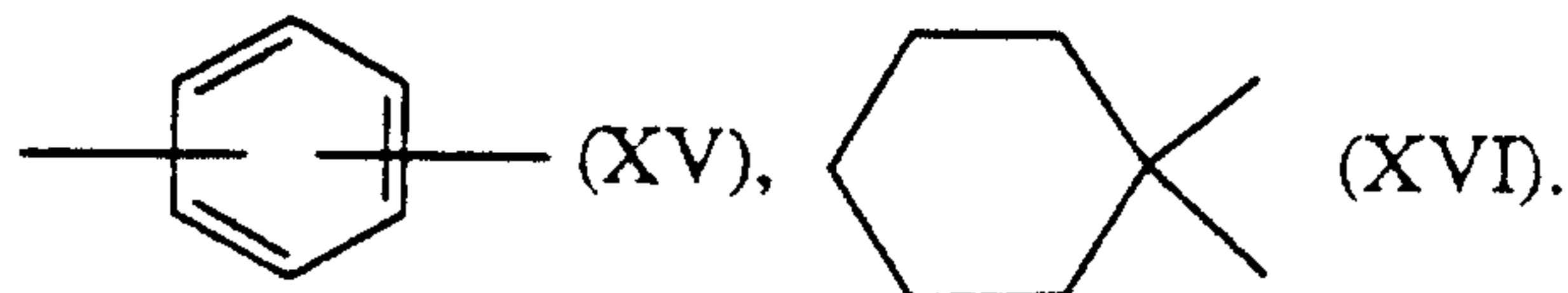
15. A composition according to any one of claims 1 to 14, wherein the substituents R_4 in formula II are each in ortho-position to the phenolic $-\text{O}-$ atom.

16. A composition according to any one of claims 1 to 15, wherein E is a group of formulae XII to XIV



wherein L is a direct bond, a group of formulae $-\text{C}_r\text{H}_{2r}-$ ($r=1$ to 20), $-\text{CH}(\text{C}_6\text{H}_5)-$, $-\text{C}(\text{CF}_3)_2-$, $-\text{S}-$, $-\text{SO}_2-$, $-\text{O}-$ or $-\text{CO}-$, or is a group of formula XV or XVI

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17. A composition according to claim 16, wherein E is a group of formulae XII, XIII or XIV, wherein L is a direct bond or a group of formula $-\text{CH}_2-$, $-\text{CH}(\text{CH}_3)-$, $-\text{CH}(\text{C}_2\text{H}_5)-$, $-\text{C}(\text{CH}_3)(\text{C}_2\text{H}_5)-$, $-\text{C}(\text{CF}_3)_2-$, $-\text{S}-$, $-\text{SO}_2-$ or $-\text{CO}-$.

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18. A composition according to any one of claims 1 to 17, wherein Y and Z have the same meaning.

19. A composition according to any one of claims 1 to 18, wherein component c) is a copolyether resin comprising 2 to 30
5 mol % of structural repeating units of formula II and 98 to 70 mol % of structural repeating units of formula III and having an average molecular weight (number average) of 2,000 to 30,000.

20. A composition according to claim 19, wherein the
10 average molecular weight (number average) is 5,000 to 20,000.

21. A composition according to any one of claims 1 to 20, which contains 5-100 % by weight of component c), based on the amount of component a).

22. A composition according to any one of claims 1 to 20,
15 which contains 10-50% by weight of component c) based on the amount of component a).

23. A composition according to any one of claims 1 to 22, wherein the molar ratio of component b):a) is (0.5-1.4):1.

24. A composition according to claim 23, wherein the
20 molar ratio is (0.7-1.2):1.

25. A process for the preparation of cured products, which comprises the use of a composition as claimed in any one of claims 1 to 24.

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