having a high glass transition temperature and a long-term heat resistance. The imide moieties of the bisimide compounds according to formula (V) of JP2015017158 A are directly connected to a phenyl moiety.

US5198515 A relates to curable biscitraconimide containing compositions, copolymers of biscitraconimides with olefinically unsaturated materials, a process for curing these copolymers, and to articles of manufacture comprising the biscitraconimide (co)polymers.

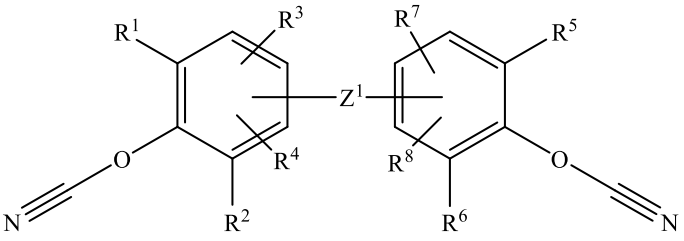
EP 2 018 401 B1 relates to prepolymer compositions comprising biscitraconimide as well as oligomers and polymers thereof and is not concerned with cyanate ester resins but with biscitraconimide resins as such, which optionally may further include a (co)curable compound selected from bismaleimides, citraconamidomaleimides, and itaconamido maleimides.

However, many of the current thermoset composite based on bismaleimide compounds have limitations or disadvantages that restrict their use as thermosetting resins in high-temperature applications and use of easy processing.

Therefore, there remains a need for new thermoset composite materials that have improved properties.

The present ~~invention~~ disclosure therefore provides a composition comprising components (a) and (b) wherein component (a) is one or more cyanate esters independently selected from

(i) a difunctional cyanate ester compound of formula (I)

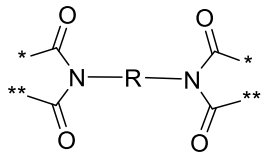


(I)

wherein

R^1 through R^8 are independently selected from the group consisting of hydrogen, linear $C_{1–10}$ alkyl, halogenated linear $C_{1–10}$ alkyl, branched $C_{4–10}$ alkyl, halogenated branched $C_{4–10}$ alkyl, $C_{3–8}$ cycloalkyl, halogenated $C_{3–8}$ cycloalkyl, $C_{1–10}$ alkoxy, halogen, phenyl and phenoxy;

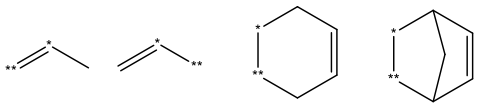
Z^1 indicates a direct bond or a divalent moiety selected from the group consisting of −O−, −S−, −S(=O)−, −S(=O)$_2$−, −CH_2−, −$CH(CH_3)$−, –$C(CH_3)_2$–,−$CH(CF_3)$−, −$C(CF_3)_2$−, −C(=O)−,



X

wherein * and ** each denotes a covalent bond to the respective C atom denoted with * and ** of a residue,

wherein the residues are identical or different and independently selected from



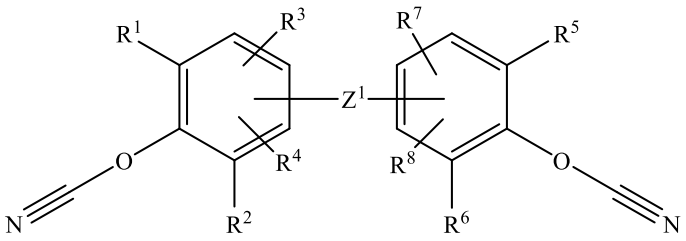
and wherein

R is independently selected from alkyl, cycloalkyl, alkyne, aryl, aralkyl and alkaryl;

and, oligomers, prepolymers, polymers or mixtures of these compounds.

In an aspect, there is provided a composition comprising components (a) and (b) wherein component (a) is one or more cyanate esters independently selected from

(i) a difunctional cyanate ester compound of formula (I)



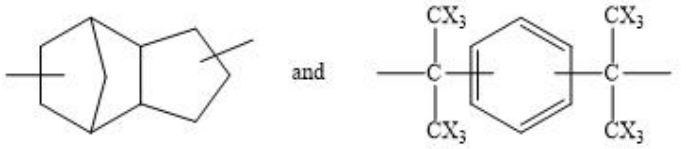
(I)

wherein

R^1 through R^8 are independently selected from the group consisting of hydrogen, linear $C_{1–10}$ alkyl, halogenated linear $C_{1–10}$ alkyl, branched $C_{4–10}$ alkyl, halogenated branched $C_{4–10}$ alkyl, $C_{3–8}$ cycloalkyl, halogenated $C_{3–8}$ cycloalkyl, $C_{1–10}$ alkoxy, halogen, phenyl and phenoxy;

Z^1 indicates a direct bond or a divalent moiety selected from the group consisting of –O–, –S–, –S(=O)–, –$S(=O)_2$–, –CH_2–, –$CH(CH_3)$–, –$C(CH_3)_2$–, –$CH(CF_3)$–, –$C(CF_3)_2$–, –C(=O)–, –$C(=CH_2)$–, –$C(=CCl_2)$–, –$Si(CH_3)_2$–, linear $C_{1–10}$ alkanediyl,

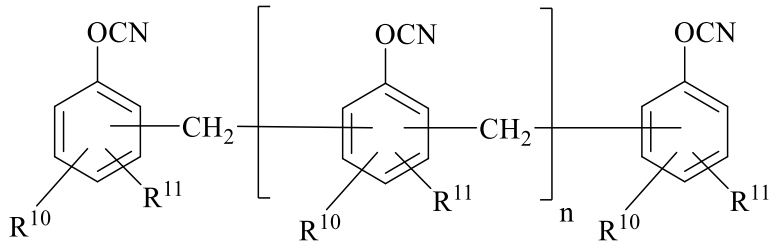
branched C_{4-10} alkanediyl, C_{3-8} cycloalkanediyl, 1,2-phenylene, 1,3-phenylene, 1,4-phenylene, $-N(R^{13})-$ wherein R^{13} is selected from the group consisting of hydrogen, linear C_{1-10} alkyl, halogenated linear C_{1-10} alkyl, branched C_{4-10} alkyl, halogenated branched C_{4-10} alkyl, C_{3-8} cycloalkyl, phenyl and phenoxy, and moieties of formulas



wherein X is independently selected from hydrogen and halogen; and oligomers, prepolymers, polymers or mixtures thereof;

and/or

(ii) a polyfunctional cyanate ester of formula (II)



(II)

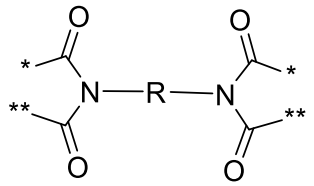
wherein

n is an integer from 1 to 20; and R^{10} and R^{11} are identical or different and independently from each other selected from the group consisting of hydrogen, linear C_{1-10} alkyl and branched C_{4-10} alkyl; and oligomers, prepolymers, polymers or mixtures thereof;

and mixtures of cyanate esters of formula (I) and (II);

and wherein

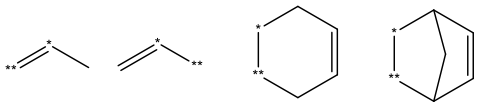
component (b) is one or more substituted bisimide compound independently selected from a compound of formula (X)



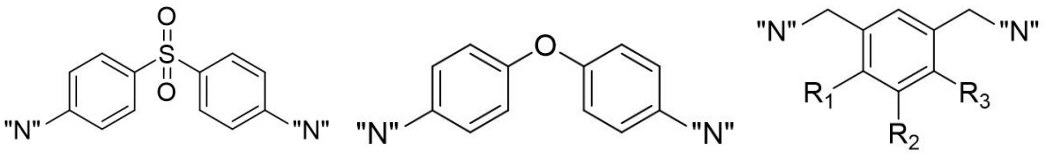
X

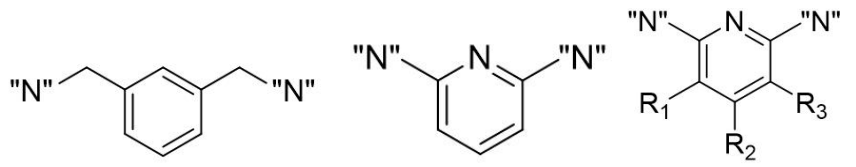
wherein * and ** each denotes a covalent bond to the respective C atom denoted with * and ** of a residue,

wherein the residues are identical or different and independently selected from



and wherein R is independently selected from linear or branched C_{1-10} alkyl, C_3-C_8 cycloalkyl, C_{2-10} alkyne or the moiety <<"N"-R-"N">>, wherein "N" denotes the point of connectivity and <<"N"-R-"N">> is an aromatic amine moiety independently selected from





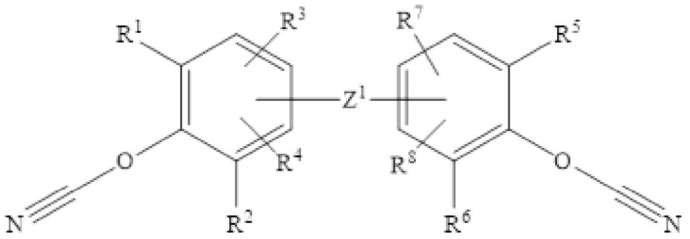
wherein

R_1, R_2, and R_3 are each independently selected from hydrogen, C_2-C_{20} alkyl, C_2-C_{20} alkene, C_2-C_{20} alkyne, halogen, NO_2, and sulfone, wherein the halogen is preferably selected from Cl, Br, F, or I;

and, oligomers, prepolymers, polymers or mixtures of these compounds.

In another aspect, there is provided a composition comprising components (a) and (b) wherein component (a) is one or more cyanate esters independently selected from

(i) a difunctional cyanate ester compound of formula (I)

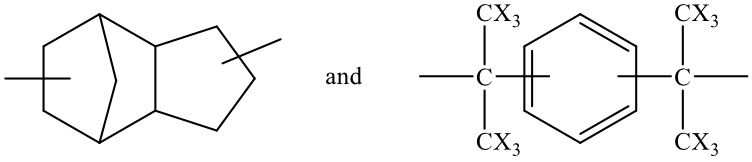


(I)

wherein

R^1 through R^8 are independently selected from the group consisting of hydrogen, linear $C_{1–10}$ alkyl, halogenated linear $C_{1–10}$ alkyl, branched $C_{4–10}$ alkyl, halogenated branched $C_{4–10}$ alkyl, $C_{3–8}$ cycloalkyl, halogenated $C_{3–8}$ cycloalkyl, $C_{1–10}$ alkoxy, halogen, phenyl and phenoxy;

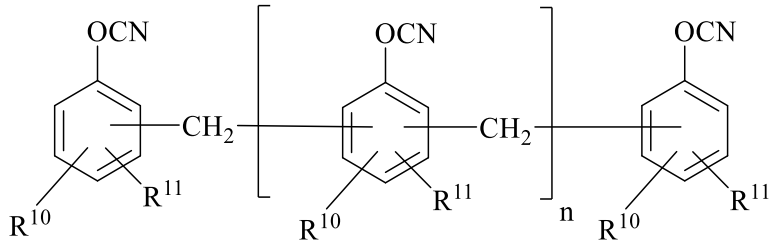
Z^1 indicates a direct bond or a divalent moiety selected from the group consisting of $–O–$, $–S–$, $–S(=O)–$, $–S(=O)_2–$, $–CH_2–$, $–CH(CH_3)–$, $–C(CH_3)_2–$, $–CH(CF_3)–$, $–C(CF_3)_2–$, $–C(=O)–$, $–C(=CH_2)–$, $–C(=CCl_2)–$, $–Si(CH_3)_2–$, linear $C_{1–10}$ alkanediyl, branched $C_{4–10}$ alkanediyl, $C_{3–8}$ cycloalkanediyl, 1,2-phenylene, 1,3-phenylene, 1,4-phenylene, $–N(R^{13})–$ wherein R^{13} is selected from the group consisting of hydrogen, linear $C_{1–10}$ alkyl, halogenated linear $C_{1–10}$ alkyl, branched $C_{4–10}$ alkyl, halogenated branched $C_{4–10}$ alkyl, $C_{3–8}$ cycloalkyl, phenyl and phenoxy, and moieties of formulas



wherein X is independently selected from hydrogen and halogen; and oligomers, prepolymers, polymers or mixtures thereof;

and/or

(ii) a polyfunctional cyanate ester of formula (II)



(II)

wherein

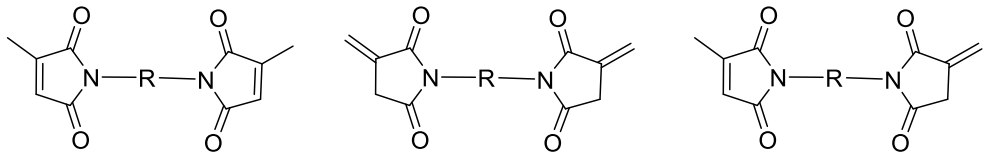
n is an integer from 1 to 20; and R^{10} and R^{11} are identical or different and independently from each other selected from the group consisting of hydrogen, linear C_{1-10} alkyl and branched C_{4-10} alkyl; and oligomers, prepolymers, polymers or mixtures thereof;

and mixtures of cyanate esters of formula (I) and (II);

and wherein

component (b) is one or more substituted bisimide independently selected from

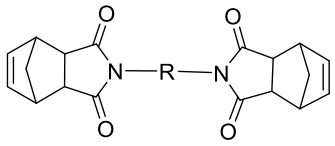
b1) at least one selected from the group of biscitraconimide compound of formula (X1), bisitaconimide compound of formula (X2) and citraconimido-itaconimide compound of formula (X3), and oligomers, prepolymers, polymers or mixtures thereof,



(X1) (X2) (X3)

or

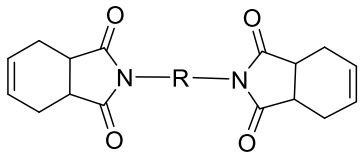
b2) a bisnadicimide compound of formula (X4) and oligomers, prepolymers, polymers or mixtures thereof,



(X4)

or

b3) a bistetrahydroimide compound of formula (X5) and oligomers, prepolymers, polymers or mixtures thereof



(X5)

wherein R is o-xylylene, and oligomers, prepolymers, polymers or mixtures thereof.

In another aspect, there is provided a method for the preparation of a composition as defined above comprising the steps of:

i) providing a mixture components as defined above; and

ii) intimately mixing the components together.

In another aspect, there is provided a method for the preparation of a thermoset composite material comprising the steps of:

i) providing a mixture components as defined above;

ii) intimately mixing the components together;

iii) casting the mixture into the desired form; and

iv) initiating polymerization of the mixture.

In another aspect, there is provided the use of a composition as defined above for producing a thermoset composite material.

The term "halogen" refers to fluorine, chlorine, bromine or iodine, preferably fluorine, chlorine or bromine.

The term substituted bisimide refers to compounds with substitutions at the C-C double bond (3 and/or 4 position) of the maleimide-group.

Alkyl substituents (either alone or as part of a larger group, such as alkoxy-) may be straight-chained or branched. Alkyl on its own or as part of another substituent is, depending upon the

number of carbon atoms mentioned, for example, methyl, ethyl, n-propyl, n-butyl, n-pentyl, n-hexyl and the isomers thereof, for example, iso-propyl, iso-butyl, sec-butyl, tert- butyl or iso-amyl.

Alkenyl substituents (either alone or as part of a larger group, e.g. alkenyloxy) can be in the form of straight or branched chains, and the alkenyl moieties, where appropriate, can be of either the (E)- or (Z)-configuration.

Alkynyl substituents (either alone or as part of a larger group, e.g. alkynyloxy) can be in the form of straight or branched chains.

Aryl groups (either alone or as part of a larger group, such as e.g. aryloxy, aryl-alkyl) are aromatic ring systems which can be in mono-, bi- or tricyclic form. Examples of such rings