(Patent Document 7) JP-A 2008-503628

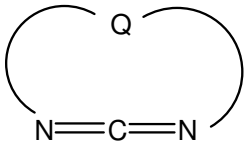
(Patent Document 8) JP-A 2011-068814

SUMMARY

In one aspect of the present disclosure, there is provided a thermosetting resin composition comprising:

(A) an epoxy resin; and

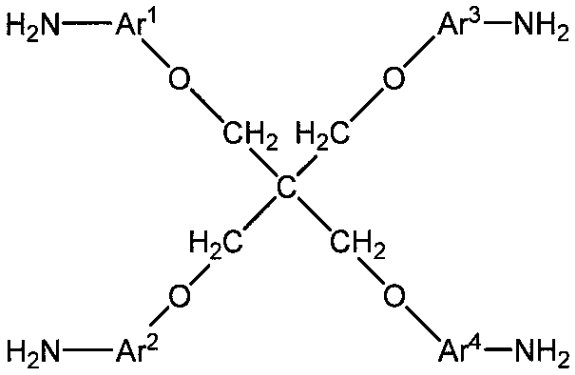
(B) a cyclic carbodiimide compound (component B) including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure:



(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group or a combination of these groups, and may contain a hetero atom or substituent; and/or

(b) a polyvalent amine-based curing agent represented by the following formula (b-i):



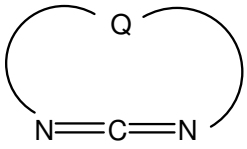
(b-i)

wherein Ar^1 to Ar^4 are each independently a phenylene group or naphthalene-diyl group which may be substituted by a

substituent.

In another aspect of the present disclosure, there is provided a process for producing a cured resin, comprising the step of heating the thermosetting resin composition disclosed herein.

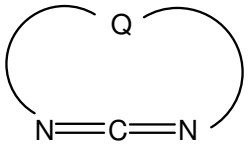
In a further aspect of the present disclosure, there is provided a method of using a cyclic carbodiimide compound including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure as a curing agent for an epoxy resin:



(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group, or a combination of these groups, and may contain a hetero atom or substituent.

In another aspect of the present disclosure, there is provided a method of using a cyclic carbodiimide compound including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure as a curing accelerator for an epoxy resin:



(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group, or a combination of these groups and may contain a hetero atom

or substituent.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide a thermosetting resin composition which does not produce a free isocyanate even when a carbodiimide compound is used and provides a cured resin having high heat resistance. The inventors of the present invention conducted intensive studies on a thermosetting resin composition which does not produce a free isocyanate even when a carbodiimide compound is used and provides a cured resin having high heat resistance. As a result, they found that a thermosetting resin composition comprising an epoxy resin and a carbodiimide compound having a specific cyclic structure does not produce a free isocyanate compound at the time of a high-temperature treatment and achieves high heat resistance. Further, they found that a carbodiimide compound having a specific cyclic structure functions effectively as a curing agent or curing accelerator to improve the characteristic properties of a thermosetting resin composition. The present invention was accomplished based on this finding.

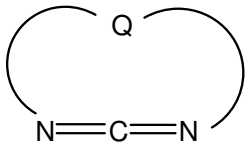
It is another object of the present invention to provide a thermosetting resin composition which makes it possible to reduce the curing temperature for the thermosetting resin composition, cures in a short time and provides a cured resin having a high glass transition temperature as well as a cured resin. As a result of intensive studies, they found that a thermosetting resin composition having a low curing temperature and a short curing time is obtained by using a polyvalent amine-based compound having a specific structure out of amine-based curing agents as a curing agent and further that a cured resin obtained by curing this thermosetting resin composition has high heat resistance. The present

CLAIMS

1. A thermosetting resin composition comprising:

(A) an epoxy resin; and

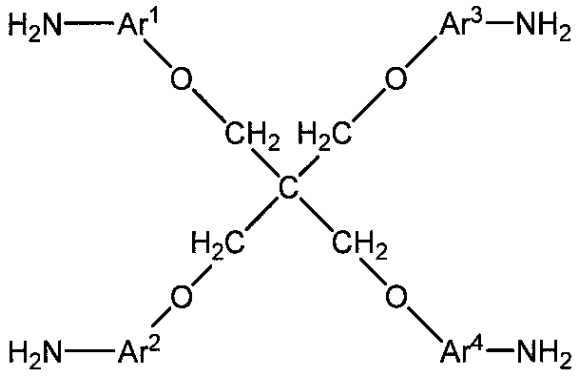
(B) a cyclic carbodiimide compound (component B) including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure:



(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group or a combination of these groups, and may contain a hetero atom or substituent; and/or

(b) a polyvalent amine-based curing agent represented by the following formula (b-i):



(b-i)

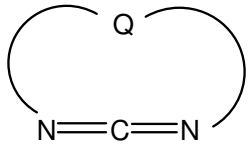
wherein Ar^1 to Ar^4 are each independently a phenylene group or naphthalene-diyl group which may be substituted by a substituent.

2. The thermosetting resin composition according to claim

1, comprising:

(A) an epoxy resin; and

(B) a cyclic carbodiimide compound including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure:

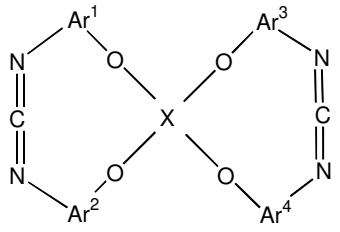


(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group, or a combination of these groups, and may contain a hetero atom or substituent.

3. The thermosetting resin composition according to claim 2, wherein the component (B) is a polyvalent cyclic carbodiimide compound having at least two carbodiimide groups in one molecule.

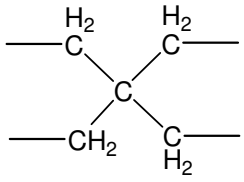
4. The thermosetting resin composition according to claim 2, wherein the component (B) is a compound represented by the following formula (B-ii):



(B-ii)

wherein X is a tetravalent group represented by the following formula (B-iii). Ar^1 to Ar^4 are each independently an orthophenylene group or 1,2-naphthalene-diyl group which may

be substituted by an alkyl group having 1 to 6 carbon atoms or phenyl group



(B-iii).

5. The thermosetting resin composition according to claim 2, wherein the content of the cyclic carbodiimide compound is 0.01 to 50 parts by weight based on 100 parts by weight of the epoxy resin.

6. The thermosetting resin composition according to claim 2, wherein the glass transition temperature of a cured resin is 2°C or more higher than the glass transition temperature of a cured resin obtained by curing a thermosetting resin composition comprising no component (B) under the same conditions.

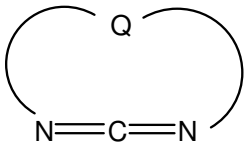
7. The thermosetting resin composition according to claim 2, further comprising a curing agent.

8. The thermosetting resin composition according to claim 2, further comprising a curing accelerator.

9. A process for producing a cured resin, comprising the step of heating the thermosetting resin composition of claim 1.

10. A method of using a cyclic carbodiimide compound including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure

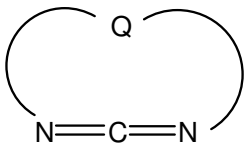
as a curing agent for an epoxy resin:



(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group, or a combination of these groups, and may contain a hetero atom or substituent.

11. A method of using a cyclic carbodiimide compound including a cyclic structure having one carbodiimide group and represented by the following formula (B-i) in which first nitrogen and second nitrogen are bonded together by a bond group and having 8 to 50 atoms forming the cyclic structure as a curing accelerator for an epoxy resin:



(B-i)

wherein Q is bivalent to tetravalent bond group which is an aliphatic group, alicyclic group, aromatic group, or a combination of these groups and may contain a hetero atom or substituent.