CARBONATE-CONTAINING EPOXY RESIN, MANUFACTURING METHOD THEREOF, EPOXY CURABLE PRODUCT PREPARED THEREBY AND METHOD FOR DEGRADING EPOXY CURABLE PRODUCT

BACKGROUND

Technical Field

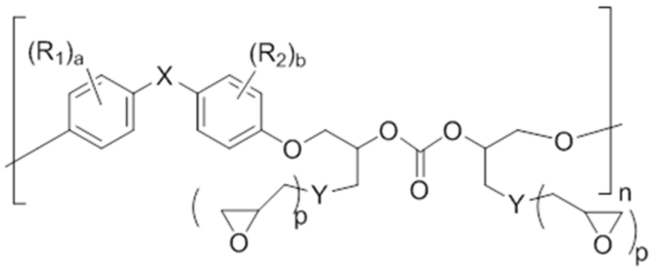
The present disclosure relates to an epoxy resin, a manufacturing method thereof, an epoxy curable product prepared thereby and a method for degrading an epoxy curable product. More particularly, the present disclosure relates to a carbonate-containing epoxy resin, a manufacturing method thereof, an epoxy curable product prepared thereby and a method for degrading an epoxy curable product.

Description of Related Art

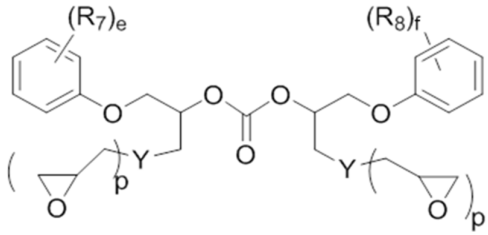
At present, the commercially available epoxy resins are mainly bisphenol A type bifunctional and novolac type multifunctional. In the synthesis, the phenolic group reacts with epichlorohydrin to form the epoxy group, and the multifunctional type is based on the phenolic resin, so formaldehyde must be used in the preparation of the phenolic resin. In addition to the environmental issues, this method is unfavorable for the preparation of the high molecular weight multifunctional epoxy. The epoxy resin has a unique three-membered ring structure, which can perform the various ring-opening reactions and can also perform the self-curing by the catalyst. However, due to the difficulty in chain growth, the final homopolymerized curable product has the disadvantage of poor performance. Therefore, most of the epoxy resins need to be copolymerized

SUMMARY

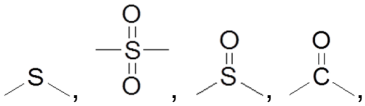
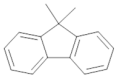
According to one aspect of the present disclosure, a carbonate-containing epoxy resin is provided. The carbonate-containing epoxy resin includes a structure represented by formula (I) or formula (II):

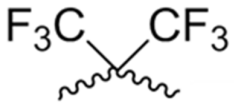


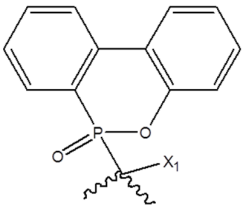
formula (I),



formula (II),

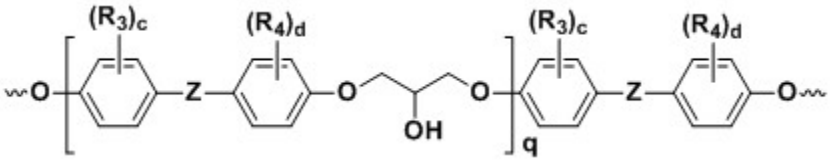
wherein R_1, R_2, R_7 and R_8 are each independently a hydrogen atom, an alkyl group of 1 to 6 carbon atoms, an allyl group, an alkoxy group of 1 to 6 carbon atoms, an aryl group of 6 to 12 carbon atoms or a halogen atom, a and b are each independently an integer from 0 to 4, e and f are each independently an integer from 0 to 5. X is a single bond, a bridging alkyl chain of 1 to 12 carbon atoms, a bridging chain with a cycloalkyl group of 3 to 12 carbon atoms, , , a bridging chain with the aryl group of 6 to 12 carbon atoms,  or a structure represented by formula (i) or formula (ii):



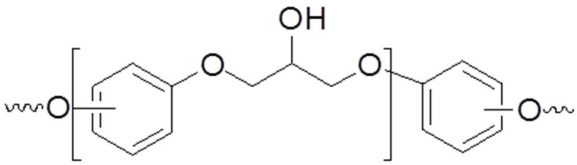


formula (i), formula (ii),

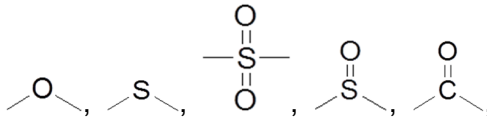
wherein X_1 is the hydrogen atom, the alkyl group of 1 to 6 carbon atoms or the aryl group of 6 to 12 carbon atoms. Y is an alkyl chain of 1 to 12 carbon atoms, an alkyl ether chain of 1 to 12 carbon atoms, isocyanurate or a structure represented by formula (iii) or formula (iv):



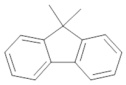
formula (iii),



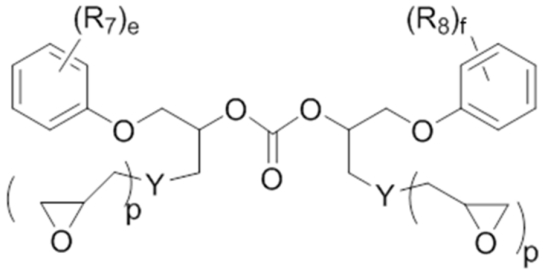
formula (iv);

wherein R_3 and R_4 are each independently the hydrogen atom, the alkyl group of 1 to 6 carbon atoms, the allyl group, the alkoxy group of 1 to 6 carbon atoms, the aryl group of 6 to 12 carbon atoms or the halogen atom, c and d are each independently an integer from 0 to 4. Z is the single bond, the bridging alkyl chain of 1 to 12 carbon atoms, the bridging chain with the cycloalkyl group of 3 to 12 carbon atoms, 

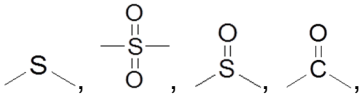
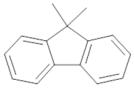
, the bridging chain

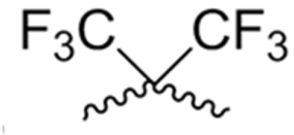
with the aryl group of 6 to 12 carbon atoms,  or the structure represented by formula (i) or formula (ii). n is a degree of polymerization, and $1 \leq n \leq 500$, p is an integer from 1 to 11, and q is an integer from 0 to 20.

According to another aspect of the present disclosure, a manufacturing method for a carbonate-containing epoxy resin includes steps as follows. An

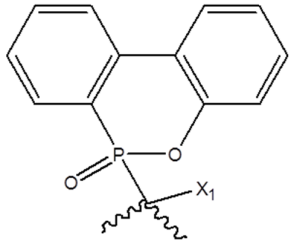


formula (II),

wherein R_1, R_2, R_7 and R_8 are each independently a hydrogen atom, an alkyl group of 1 to 6 carbon atoms, an allyl group, an alkoxy group of 1 to 6 carbon atoms, an aryl group of 6 to 12 carbon atoms or a halogen atom, a and b are each independently an integer from 0 to 4, e and f are each independently an integer from 0 to 5. X is a single bond, a bridging alkyl chain of 1 to 12 carbon atoms, a bridging chain with a cycloalkyl group of 3 to 12 carbon atoms, , , a bridging chain with the aryl group of 6 to 12 carbon atoms,  or a structure represented by formula (i) or formula (ii):

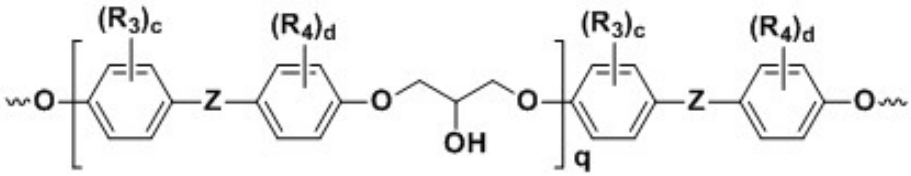


formula (i),

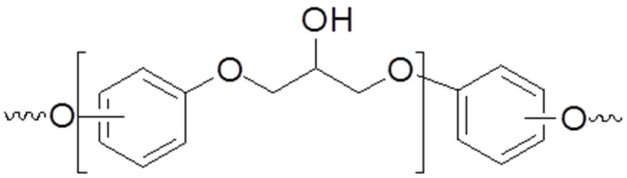


formula (ii),

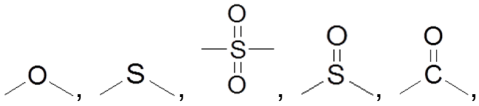
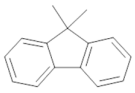
wherein X_1 is the hydrogen atom, the alkyl group of 1 to 6 carbon atoms or the aryl group of 6 to 12 carbon atoms. Y is an alkyl chain of 1 to 12 carbon atoms, an alkyl ether chain of 1 to 12 carbon atoms, isocyanurate or a structure represented by formula (iii) or formula (iv):



formula (iii),



formula (iv);

wherein R_3 and R_4 are each independently the hydrogen atom, the alkyl group of 1 to 6 carbon atoms, the allyl group, the alkoxy group of 1 to 6 carbon atoms, the aryl group of 6 to 12 carbon atoms or the halogen atom, c and d are each independently an integer from 0 to 4. Z is the single bond, the bridging alkyl chain of 1 to 12 carbon atoms, the bridging chain with the cycloalkyl group of 3 to 12 carbon atoms, , the bridging chain with the aryl group of 6 to 12 carbon atoms,  or the structure represented by formula (i) or formula (ii). n is a degree of polymerization, and $1 \leq n \leq 500$, m is an integer from 2 to 12, p is an integer from 1 to 11, and q is an integer from 0 to 20.

According to further another aspect of the present disclosure, an epoxy curable product is provided. The epoxy curable product is obtained by performing a curing reaction with the carbonate-containing epoxy resin according to the aforementioned aspect, wherein the curing reaction is completed by mixing the carbonate-containing epoxy resin and a curing agent.

According to still another aspect of the present disclosure, a method for degrading an epoxy curable product includes steps as follows. The epoxy curable product according to the aforementioned aspect is provided. A degrading step is performed, wherein an amine group-containing compound is reacted with the epoxy curable product to degrade the epoxy curable product.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure can be more fully understood by reading the following detailed description of the embodiment, with reference made to the accompanying drawings as follows.

Fig. 1 is a flow chart of a manufacturing method for a carbonate-containing epoxy resin according to one embodiment of the present disclosure.

Fig. 2 is a flow chart of a manufacturing method for an epoxy curable product according to another embodiment of the present disclosure.

Fig. 3 is a flow chart of a method for degrading an epoxy curable product according to further embodiment of the present disclosure.

Fig. 4 is a ^{1}H-NMR spectrum of Example 1.

Fig. 5 is a ^{1}H-NMR spectrum of Example 2 to Example 4.

Fig. 6 is a ^{1}H-NMR spectrum of Example 19.

DETAILED DESCRIPTION

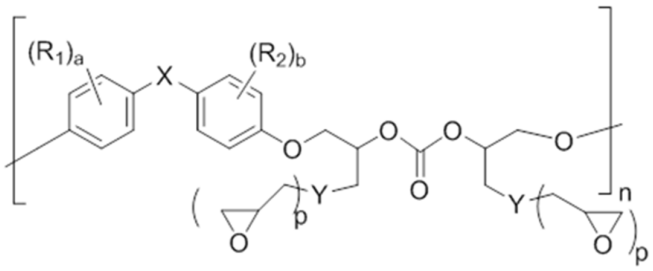
The present disclosure will be further exemplified by the following specific embodiments. However, the embodiments can be applied to various inventive concepts and can be embodied in various specific ranges. The specific embodiments are only for the purposes of description, and are not limited to these practical details thereof.

In the present disclosure, the compound structure can be represented by a skeleton formula, and the representation can omit the carbon atom, the hydrogen atom and the carbon-hydrogen bond. In the case that the functional group is depicted clearly in the structural formula, the depicted one is preferred.

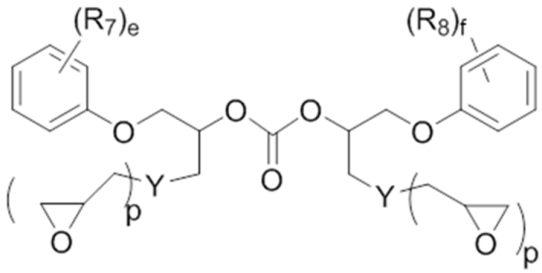
In the present disclosure, in order to concise and smooth, “carbonate-containing epoxy resin, comprising a structure represented by formula (I)” can be represented as a carbonate-containing epoxy resin represented by formula (I) or

WHAT IS CLAIMED IS:

1. A carbonate-containing epoxy resin, comprising a structure represented by formula (I) or formula (II):

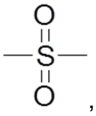
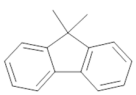


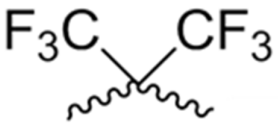
formula (I),

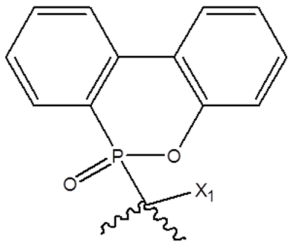


formula (II);

wherein R_1, R_2, R_7 and R_8 are each independently a hydrogen atom, an alkyl group of 1 to 6 carbon atoms, an allyl group, an alkoxy group of 1 to 6 carbon atoms, an aryl group of 6 to 12 carbon atoms or a halogen atom, a and b are each independently an integer from 0 to 4, e and f are each independently an integer from 0 to 5;

wherein X is a single bond, a bridging alkyl chain of 1 to 12 carbon atoms, a bridging chain with a cycloalkyl group of 3 to 12 carbon atoms, , , , , , a bridging chain with the aryl group of 6 to 12 carbon atoms,  or a structure represented by formula (i) or formula (ii):

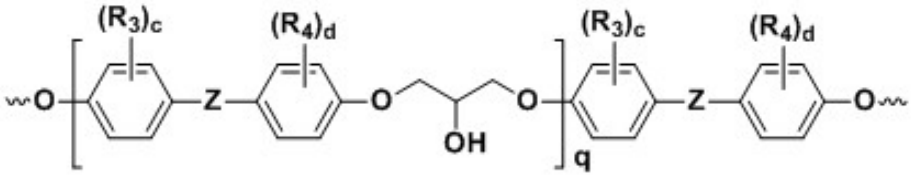




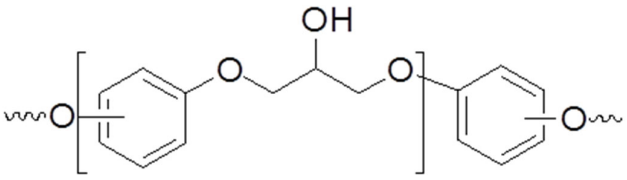
formula (i), formula (ii);

wherein X_1 is the hydrogen atom, the alkyl group of 1 to 6 carbon atoms or the aryl group of 6 to 12 carbon atoms;

wherein Y is an alkyl chain of 1 to 12 carbon atoms, an alkyl ether chain of 1 to 12 carbon atoms, isocyanurate or a structure represented by formula (iii) or formula (iv):



formula (iii),

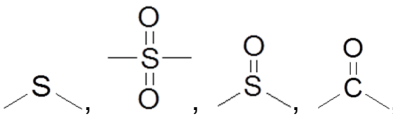
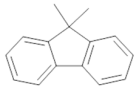


formula (iv);

wherein R_3 and R_4 are each independently the hydrogen atom, the alkyl group of 1 to 6 carbon atoms, the allyl group, the alkoxy group of 1 to 6 carbon atoms, the aryl group of 6 to 12 carbon atoms or the halogen atom, c and d are each independently an integer from 0 to 4;

wherein Z is the single bond, the bridging alkyl chain of 1 to 12 carbon atoms, the bridging chain with the cycloalkyl group of 3 to 12 carbon atoms, 

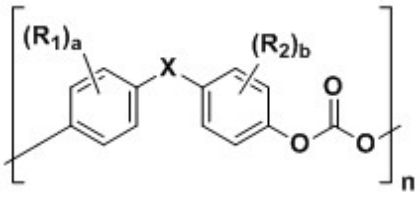
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, the bridging chain with the aryl group of 6 to 12 carbon atoms,  or the structure represented by formula (i) or formula (ii);

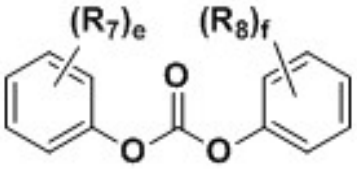
wherein n is a degree of polymerization, and $1 \leq n \leq 500$, p is an integer from 1 to 11, and q is an integer from 0 to 20.

2. A manufacturing method for a carbonate-containing epoxy resin, comprising:

providing an aromatic carbonate group-containing structure, wherein the aromatic carbonate group-containing structure comprises a structure represented by formula (A1) or formula (A2):



formula (A1),



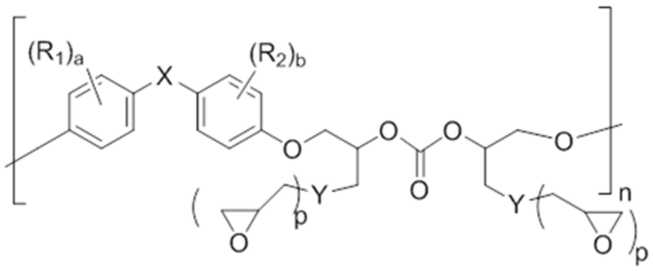
formula (A2);

providing an epoxy group-containing structure, wherein the epoxy group-containing structure comprises a structure represented by formula (B):

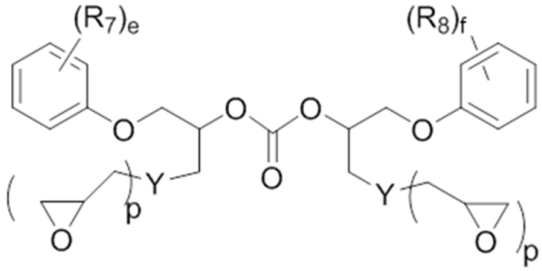


formula (B); and

performing a catalyzing step, wherein the aromatic carbonate group-containing structure is mixed with the epoxy group-containing structure, and then at a catalysis of a catalyst to obtain a carbonate-containing epoxy resin, which comprises a structure represented by formula (I) or formula (II):

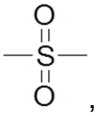
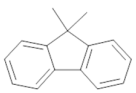


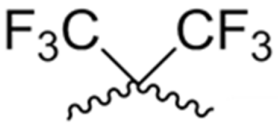
formula (I),

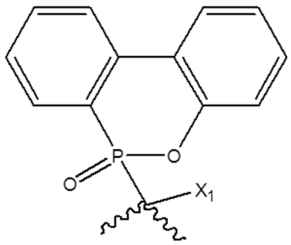


formula (II);

wherein R_1, R_2, R_7 and R_8 are each independently a hydrogen atom, an alkyl group of 1 to 6 carbon atoms, an allyl group, an alkoxy group of 1 to 6 carbon atoms, an aryl group of 6 to 12 carbon atoms or a halogen atom, a and b are each independently an integer from 0 to 4, e and f are each independently an integer from 0 to 5;

wherein X is a single bond, a bridging alkyl chain of 1 to 12 carbon atoms, a bridging chain with a cycloalkyl group of 3 to 12 carbon atoms, , , , , , the bridging chain with the aryl group of 6 to 12 carbon atoms,  or a structure represented by formula (i) or formula (ii):

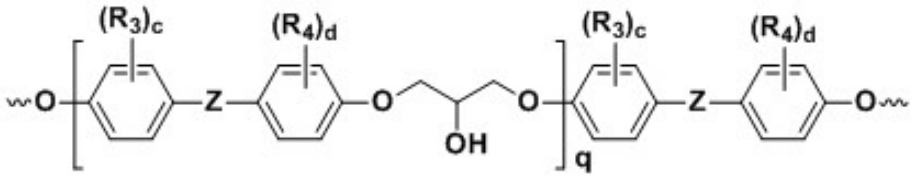




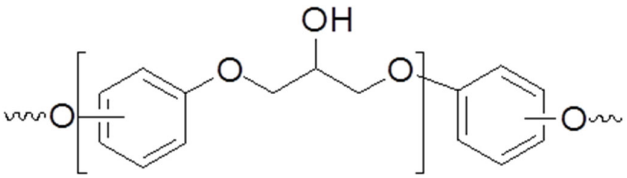
formula (i), formula (ii);

wherein X_1 is the hydrogen atom, the alkyl group of 1 to 6 carbon atoms or the aryl group of 6 to 12 carbon atoms;

wherein Y is an alkyl chain of 1 to 12 carbon atoms, an alkyl ether chain of 1 to 12 carbon atoms, isocyanurate or a structure represented by formula (iii) or formula (iv):



formula (iii),

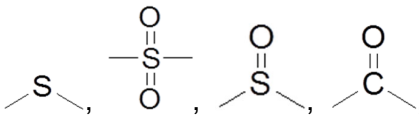
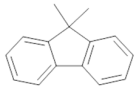


formula (iv);

wherein R_3 and R_4 are each independently the hydrogen atom, the alkyl group of 1 to 6 carbon atoms, the allyl group, the alkoxy group of 1 to 6 carbon atoms, the aryl group of 6 to 12 carbon atoms or the halogen atom, c and d are each independently an integer from 0 to 4;

wherein Z is the single bond, the bridging alkyl chain of 1 to 12 carbon atoms, the bridging chain with the cycloalkyl group of 3 to 12 carbon atoms, 

,

, the bridging chain with the aryl group of 6 to 12 carbon atoms,  or the structure represented by formula (i) or formula (ii);

wherein n is a degree of polymerization, and $1 \leq n \leq 500$, m is an integer from 2 to 12, p is an integer from 1 to 11, and q is an integer from 0 to 20.

3. The manufacturing method for the carbonate-containing epoxy resin of claim 2, wherein the catalyst is selected from a group consisting of 4-dimethylaminopyridine, imidazole, pyridine, 2-methylimidazole, 3-methylimidazole and 2-ethyl-4-methylimidazole.

4. The manufacturing method for the carbonate-containing epoxy resin of claim 3, wherein an added amount of the catalyst is ranged from 0.1% by weight to 5% by weight of an amount of the epoxy group-containing structure.

5. The manufacturing method for the carbonate-containing epoxy resin of claim 2, wherein an equivalence ratio of an epoxy group of the epoxy group-containing structure to a carbonate group of the aromatic carbonate group-containing structure is 1.3 to 10.0.

6. An epoxy curable product, which is obtained by performing a curing reaction with the carbonate-containing epoxy resin of claim 1, wherein the curing reaction is completed by mixing the carbonate-containing epoxy resin and a curing agent.

7. The epoxy curable product of claim 6, wherein the curing agent is a phenolic resin, an amine compound, an active ester compound, a carboxylic acid compound, a cyanate ester compound, an isocyanate compound, an anhydride compound, benzoxazine, polycarbonate or a mixture thereof.

8. The epoxy curable product of claim 6, wherein a curing temperature of the curing reaction is 180°C to 240°C.

9. A method for degrading an epoxy curable product, comprising:

providing the epoxy curable product of claim 6; and

performing a degrading step, wherein an amine group-containing compound is reacted with the epoxy curable product to degrade the epoxy curable product.