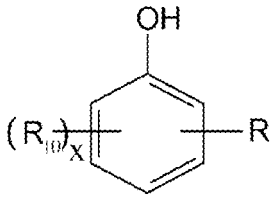
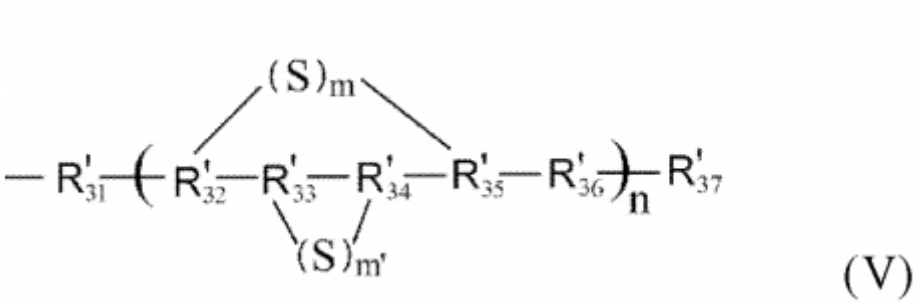
Claims

1. A phenol derivative, which is characterized in that the phenol derivative has a structure as represented by the formula (I-3):

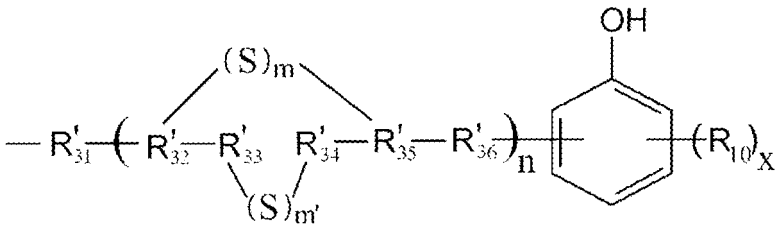


(I-3)

In the general formula (I-3), group R is selected from a group represented by the formula (V) and a group represented by the formula (VIII); group R is located at the meta-position or the para-position of the phenolic hydroxyl group; x is 1 or 2, one or two groups R_{10} are located at the ortho-position of the phenolic hydroxyl group, and are each independently selected from C_{1-4} linear or branched alkyl;



(V)



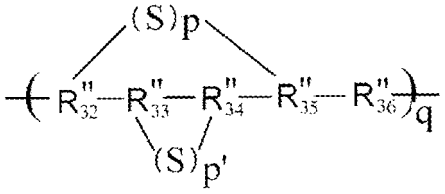
(VIII)

In the formula (V) , group R_{31}' is each independently selected from C_{1-20} linear or branched alkylene (preferably selected from C_{1-4} linear or branched alkylene); groups R_{32}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{33}' in n repeating units are,

identical to or different from each other, each independently selected from single bond, divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{34}' in n repeating units are, identical to or different from each other, each independently selected from single bond, divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{35}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{36}' in n repeating units are, identical to or different from each other, each independently selected from single bond, C_{1-4} linear or branched alkylene; group R_{37}' is selected from hydrogen and C_{1-20} linear or branched alkyl (preferably selected from hydrogen and C_{1-4} linear or branched alkyl); n is an integral number of 1-10 (preferably an integral number of 1-3); the numbers m in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); the numbers m' in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); m+m'>0, in each repeating unit of the formulae (V), when m is greater than 0, the linking group formed by m sulfur atoms is bonded to groups R_{32}' and R_{35}'; when m' is greater than 0, the linking group formed by m' sulfur atoms is bonded to groups R_{33}' and R_{34}'; in each repeating unit of the formulae (V) , when group R_{33}' is single bond, one end connected to group R_{33}' of the linking group formed by m' sulfur atoms is bonded to group R_{32}', when group R_{34}' is single bond, one end connected to group R_{34}' of the linking group formed by m' sulfur atoms is bonded to group R_{35}';

In the formula (VIII), group R_{31}' is each independently selected from C_{1-20} linear or branched alkylene (preferably selected from C_{1-4} linear or branched alkylene); groups R_{32}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{33}' in n repeating units are, identical to or different from each other, each independently selected from H and divalent C_{1-4} linear or branched alkyl; groups R_{34}' in n repeating units are, identical to or different from each other, each independently selected from H and divalent C_{1-4} linear or branched alkyl; groups R_{35}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{36}' in n repeating units are, identical to or different from each other, each independently selected from single bond, C_{1-4} linear or branched alkylene; n is an integral number of 1-10 (preferably an integral number of 1-3); the numbers m in n repeating units are, identical to or different from

each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); the numbers m' in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5), m+m'>0; in each repeating unit of the formula (VIII), when m is greater than 0, the linking group formed by m sulfur atoms is bonded to groups R_{32}' and R_{35}'; when m' is greater than 0, the linking group formed by m' sulfur atoms is bonded to groups R_{33}' and R_{34}'; in each repeating unit of the formula (VIII), when group R_{33}' is H, one end connected to group R_{33}' of the linking group formed by m' sulfur atoms is bonded to group R_{32}'; when group R_{34}' is H, one end connected to group R_{34}' of the linking group formed by m' sulfur atoms is bonded to group R_{35}'; in each repeating unit of the formula (VIII), groups R_{31}' and R_{36}' can be each independently replaced by a group represented by the formula (VIII-1); in each repeating unit of the formula (VIII), groups R_{32}', R_{33}', R_{34}' and R_{35}' can be each independently replaced by a group represented by the formula (V),



(VIII-1)

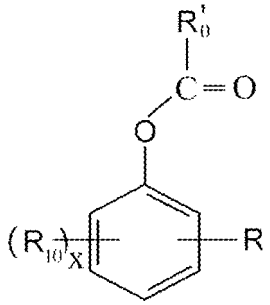
In the formula (VIII-1), groups R_{32}" in q repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{33}" in q repeating units are, identical to or different from each other, each independently selected from single bond and divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{34}" in q repeating units are, identical to or different from each other, each independently selected from single bond, divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{35}" in q repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{36}" in q repeating units are, identical to or different from each other, each independently selected from single bond, C_{1-4} linear or branched alkylene; q is an integral number of 1-3; the numbers p in q repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); the numbers p' in q repeating units are, identical to or different from each other, each

independently selected from an integral number of 0-10 (preferably an integral number of 0-5); in each repeating unit of the formula (VIII-1), when p is greater than 0, the linking group formed by p sulfur atoms is bonded to groups R_{32}" and R_{35}"; when p' is greater than 0, the linking group formed by p' sulfur atoms is bonded to groups R_{33}" and R_{34}"; in each repeating unit of the formula (VIII-1), when group R_{33}" is single bond, one end connected to group R_{33}" of the linking group formed by p' sulfur atoms is bonded to group R_{32}", when group R_{34}" is single bond, one end connected to group R_{34}" of the linking group formed by p' sulfur atoms is bonded to group R_{35}";

More preferably, group R is located at the meta-position of the phenolic hydroxyl group; x is 1 or 2, one or two groups R_{10} are located at the ortho-position of the phenolic hydroxyl group, and are each independently selected from C_{1-4} linear or branched alkyl;

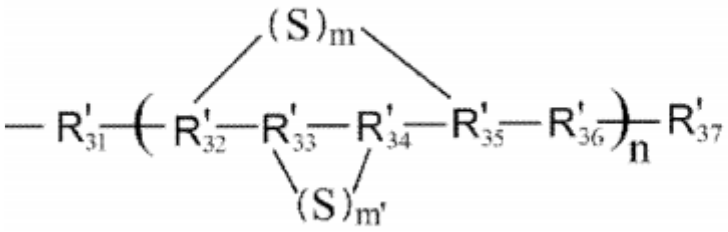
Further preferably, group R is located at the meta-position of the phenolic hydroxyl group; x is 1, group R_{10} is located at the ortho-position of the phenolic hydroxyl group and at the para-position of the group R, group R_{10} is selected from C_{1-4} linear or branched alkyl.

2. A phenol derivative, which is characterized in that the phenol derivative has a structure as represented by the formula (I-4):

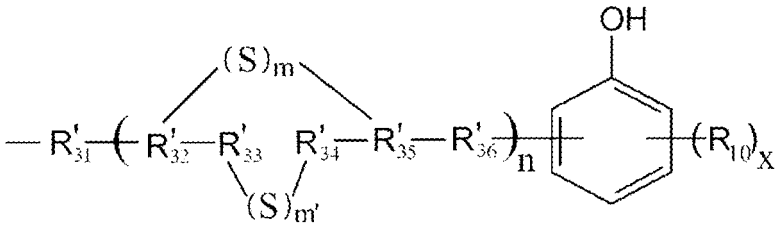


(I-4)

In the general formula (I-4), group R_0' is C_{1-20} linear or branched alkyl; group R is selected from a group represented by the formula (V) and a group represented by the formula (VIII); group R is located at the meta-position or the para-position of the phenolic hydroxyl group; x is 0, 1 or 2, one or two groups R_{10} that are present are located at the ortho-position of the phenolic hydroxyl group, and are each independently selected from C_{1-4} linear or branched alkyl;



(V)

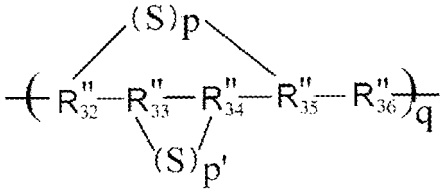


(VIII)

In the formula (V) , group R_{31}' is each independently selected from C_{1-20} linear or branched alkylene (preferably selected from C_{1-4} linear or branched alkylene); groups R_{32}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{33}' in n repeating units are, identical to or different from each other, each independently selected from single bond, divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{34}' in n repeating units are, identical to or different from each other, each independently selected from single bond, divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{35}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{36}' in n repeating units are, identical to or different from each other, each independently selected from single bond, C_{1-4} linear or branched alkylene; group R_{37}' is selected from hydrogen and C_{1-20} linear or branched alkyl (preferably selected from hydrogen and C_{1-4} linear or branched alkyl); n is an integral number of 1-10 (preferably an integral number of 1-3); the numbers m in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); the numbers m' in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); $m+m'>0$, in each repeating unit of the formulae (V), when m is greater than 0, the linking group formed by m sulfur atoms is bonded to groups R_{32}' and R_{35}'; when m' is

greater than 0, the linking group formed by m' sulfur atoms is bonded to groups R_{33}' and R_{34}'; in each repeating unit of the formulae (V) , when group R_{33}' is single bond, one end connected to group R_{33}' of the linking group formed by m' sulfur atoms is bonded to group R_{32}', when group R_{34}' is single bond, one end connected to group R_{34}' of the linking group formed by m' sulfur atoms is bonded to group R_{35}';

In the formula (VIII), group R_{31}' is each independently selected from C_{1-20} linear or branched alkylene (preferably selected from C_{1-4} linear or branched alkylene); groups R_{32}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{33}' in n repeating units are, identical to or different from each other, each independently selected from H and divalent C_{1-4} linear or branched alkyl; groups R_{34}' in n repeating units are, identical to or different from each other, each independently selected from H and divalent C_{1-4} linear or branched alkyl; groups R_{35}' in n repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{36}' in n repeating units are, identical to or different from each other, each independently selected from single bond, C_{1-4} linear or branched alkylene; n is an integral number of 1-10 (preferably an integral number of 1-3); the numbers m in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); the numbers m' in n repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5), m+m'>0; in each repeating unit of the formula (VIII), when m is greater than 0, the linking group formed by m sulfur atoms is bonded to groups R_{32}' and R_{35}'; when m' is greater than 0, the linking group formed by m' sulfur atoms is bonded to groups R_{33}' and R_{34}'; in each repeating unit of the formula (VIII), when group R_{33}' is H, one end connected to group R_{33}' of the linking group formed by m' sulfur atoms is bonded to group R_{32}'; when group R_{34}' is H, one end connected to group R_{34}' of the linking group formed by m' sulfur atoms is bonded to group R_{35}'; in each repeating unit of the formula (VIII), groups R_{31}' and R_{36}' can be each independently replaced by a group represented by the formula (VIII-1); in each repeating unit of the formula (VIII), groups R_{32}', R_{33}', R_{34}' and R_{35}' can be each independently replaced by a group represented by the formula (V),



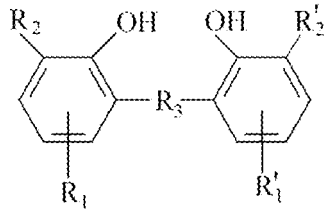
(VIII-1)

In the formula (VIII-1), groups R_{32}" in q repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{33}" in q repeating units are, identical to or different from each other, each independently selected from single bond and divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{34}" in q repeating units are, identical to or different from each other, each independently selected from single bond, divalent or tervalent C_{1-4} linear or branched alkyl; groups R_{35}" in q repeating units are, identical to or different from each other, each independently selected from divalent, tervalent or tetravalent C_{1-4} linear or branched alkyl; groups R_{36}" in q repeating units are, identical to or different from each other, each independently selected from single bond, C_{1-4} linear or branched alkylene; q is an integral number of 1-3; the numbers p in q repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); the numbers p' in q repeating units are, identical to or different from each other, each independently selected from an integral number of 0-10 (preferably an integral number of 0-5); in each repeating unit of the formula (VIII-1), when p is greater than 0, the linking group formed by p sulfur atoms is bonded to groups R_{32}" and R_{35}"; when p' is greater than 0, the linking group formed by p' sulfur atoms is bonded to groups R_{33}" and R_{34}"; in each repeating unit of the formula (VIII-1), when group R_{33}" is single bond, one end connected to group R_{33}" of the linking group formed by p' sulfur atoms is bonded to group R_{32}", when group R_{34}" is single bond, one end connected to group R_{34}" of the linking group formed by p' sulfur atoms is bonded to group R_{35}";

More preferably, group R is located at the meta-position of the phenolic hydroxyl group; x is 0, 1 or 2, one or two groups R_{10} that are present are located at the ortho-position of the phenolic hydroxyl group, and each independently selected from C_{1-4} linear or branched alkyl.

3. A phenol derivative, which is characterized in that the phenol derivative has a structure as

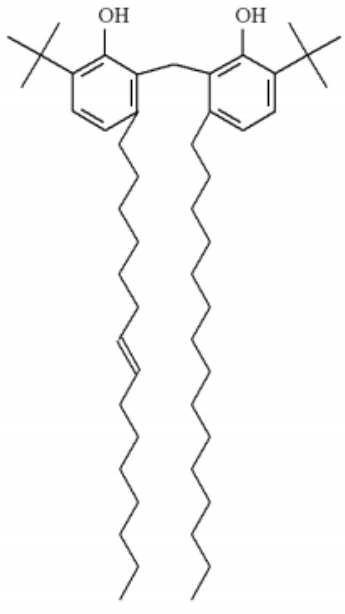
represented by the formula (I-5):

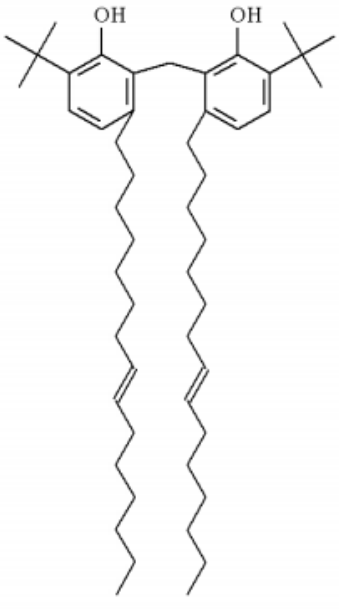


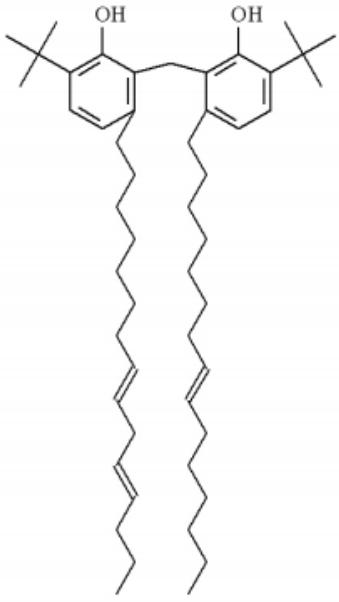
(I-5)

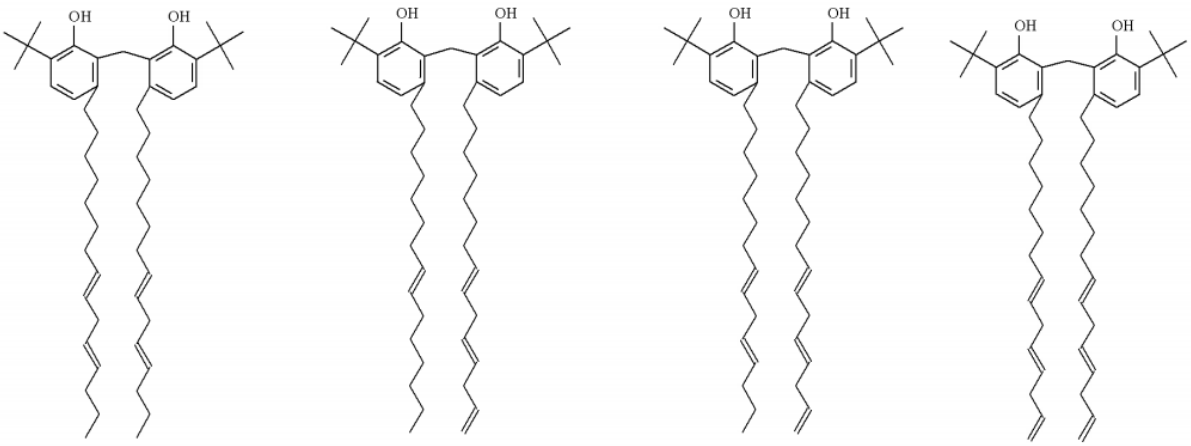
Wherein, R_1 and R_1' can be identical or different and each independently selected from $C_nH_{(2n+m)}$, n is an integral number of 3-30 (preferably an integral number of 5-20, most preferably an integral number of 10-18, for example can be 10, 11, 12, 13, 14, 15, 16, 17, 18), m is -1, -3 or -5 (preferably -1 or -3); R_2 and R_2' can be identical or different and each independently selected from C_{1-6} linear or branched alkyl (preferably selected from C_1-C_4 linear or branched alkyl, most preferably tert-butyl); R_3 is selected from C_1-C_6 linear or branched alkylene (preferably selected from C_1-C_4 linear or branched alkylene, most preferably methylene).

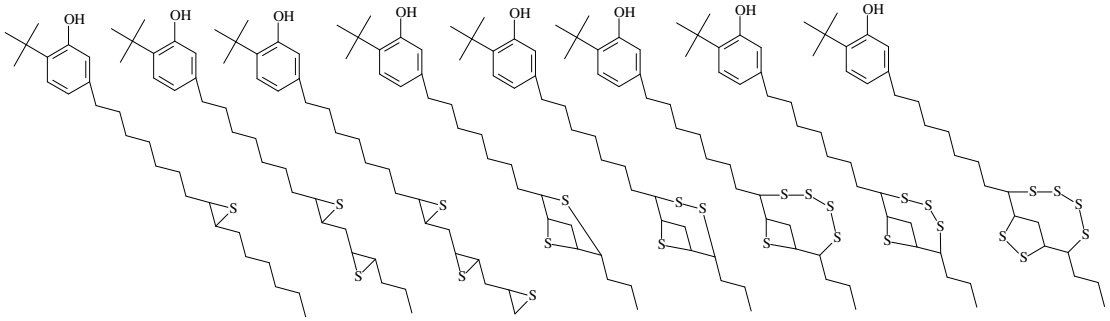
4. The phenol derivative according to any of claims 1-3, which is characterized in that the phenol derivative is selected from the following specific compounds or a mixture thereof in any proportion:

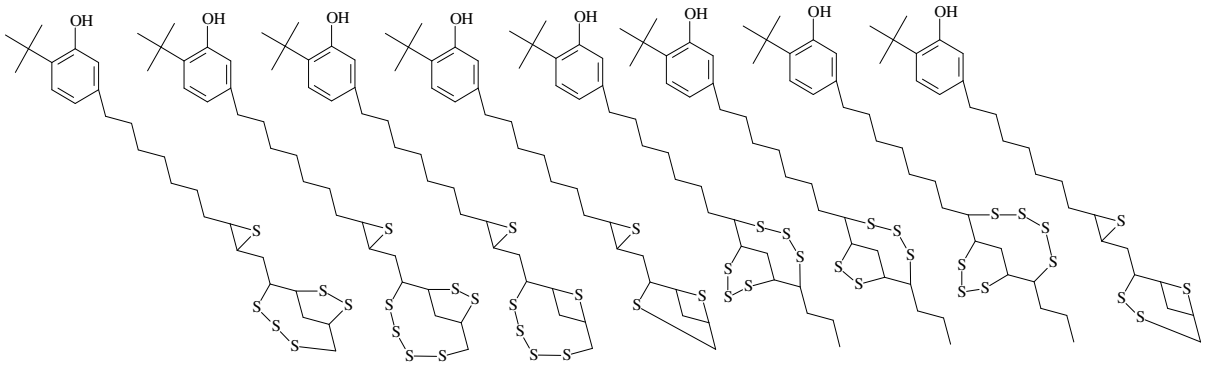












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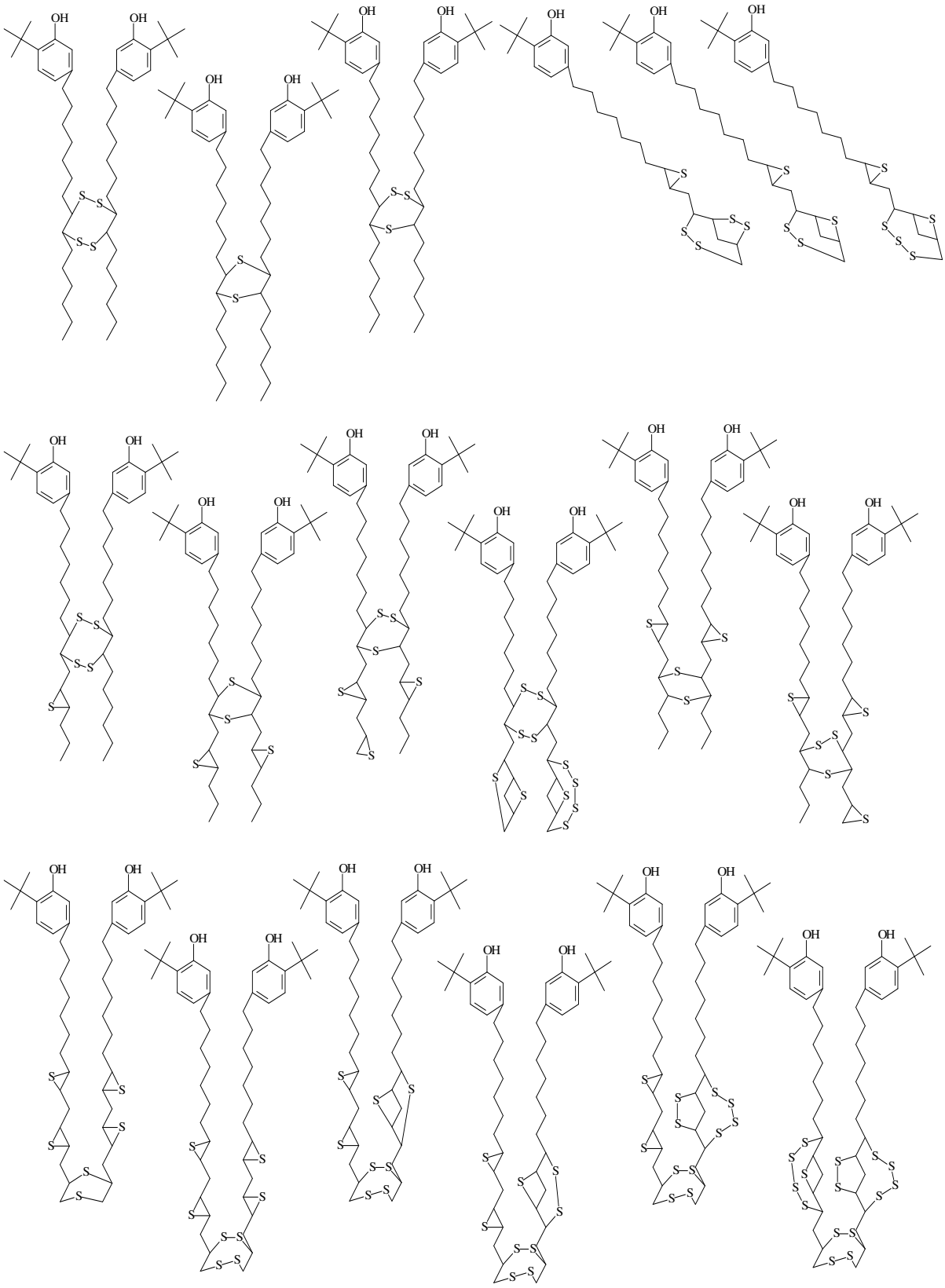
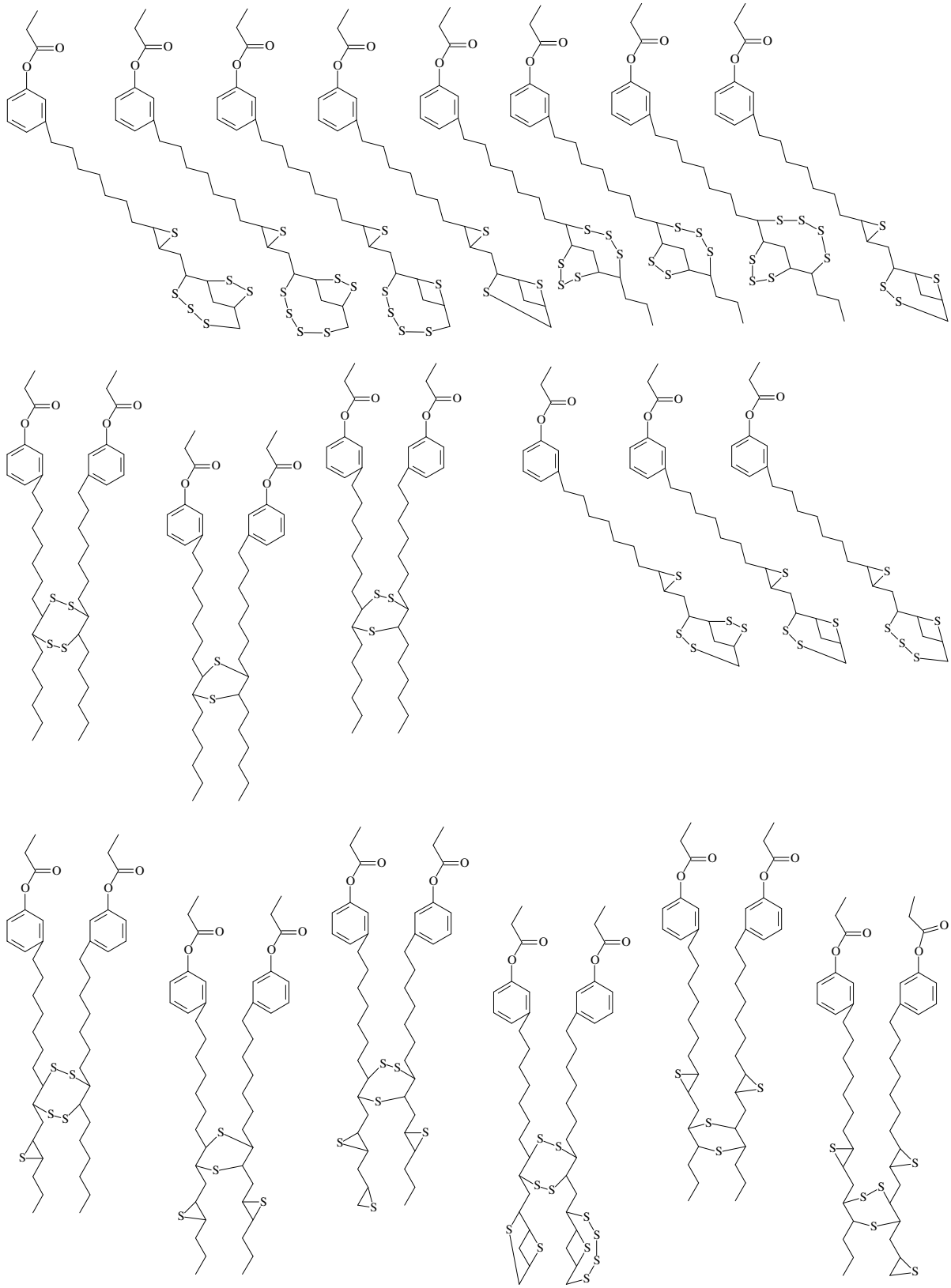
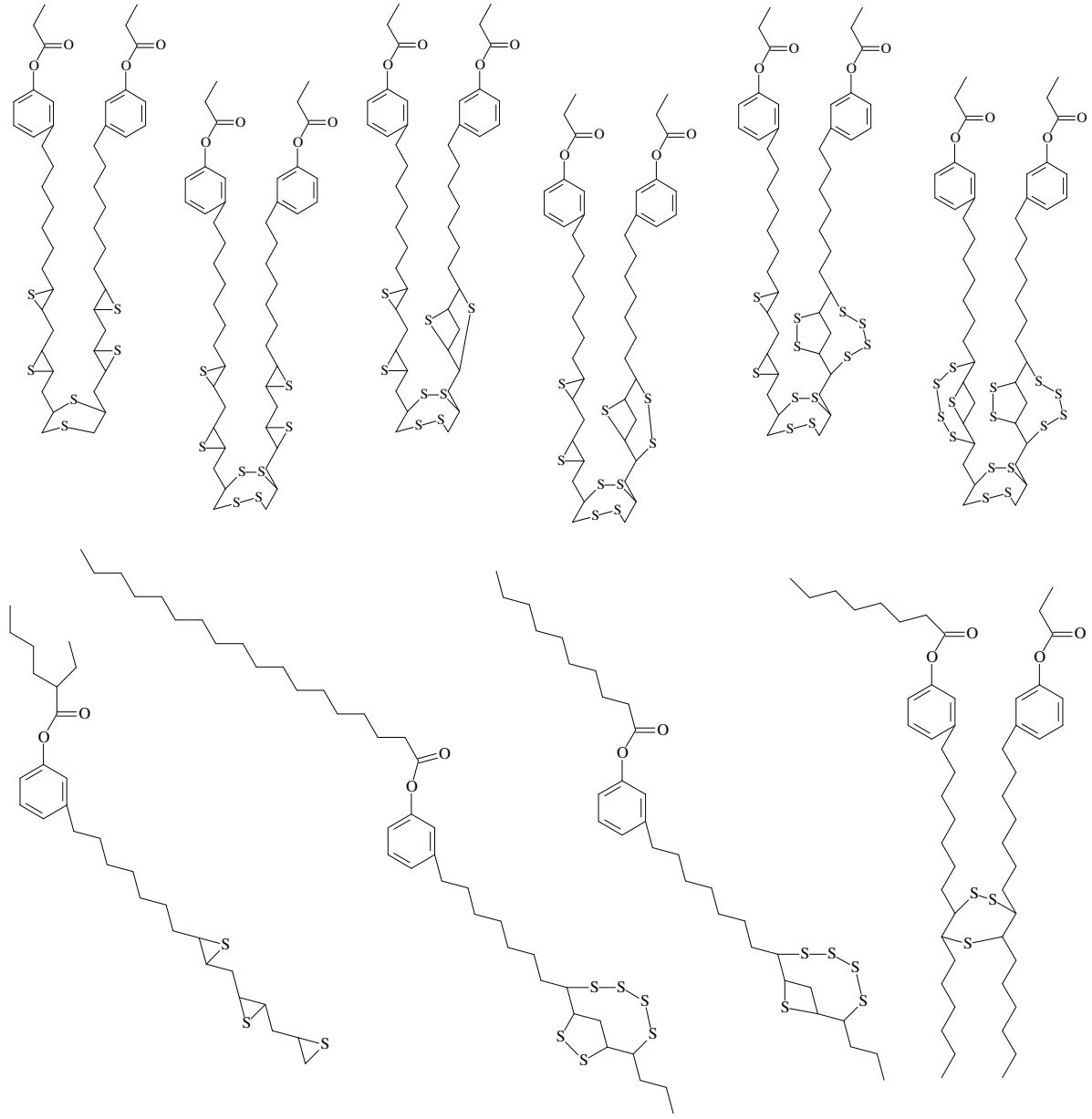






Wherein, R_0, R_2 and R_3 are defined as above (preferably, groups R_0 are ethyl, groups R_2 are each independently selected from C_2-C_{18} alkyl, groups R_3 are each independently selected from C_2-C_{18} alkyl).

5. A process of preparing a phenol derivative according to any one of claims 1-4, comprising subjecting the compound represented by the general formula (I') to a first step of at least one reaction of a sulfurization reaction and a coupling reaction, and to a second step of one or more reactions of an esterification reaction, and an alkylation reaction;

the compound represented by the general formula (I') is subjected to a first step of at least one

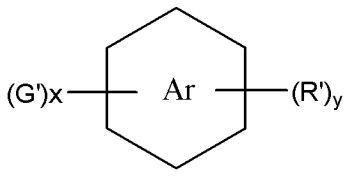
reaction of a sulfurization reaction and a coupling reaction, followed by one or more reactions of an esterification reaction, an alkylation reaction in the second step; or the compound represented by the general formula (I') can be subjected to one or more reactions of an esterification reaction and an alkylation reaction in the second step, followed by at least one reaction of a sulfurization reaction and a coupling reaction in the first step;

wherein the sulfurization reaction is to react -C=C- in the compound represented by the formula (I') with a sulfurizing agent, and the esterification reaction is to react the reaction product obtained from subjecting the compound represented by the formula (I') to a sulfurization reaction in the first step with an esterifying agent, or

the esterification reaction is to react a hydroxy group on the ring group of the compound represented by the formula (I') with an esterifying agent, and the sulfurization reaction is to react a product obtained from subjecting the compound represented by the formula (I') to esterification reaction in the second step with a sulfurizing agent, or

the alkylation reaction is to react ortho-position hydrogens of the hydroxy groups on the ring group present in the compound represented by the formula (I') with an alkylating agent, and the sulfurization reaction is to react a product obtained from subjecting the compound represented by the formula (I') to alkylation reaction in the second step with a sulfurizing agent, or

the alkylation reaction is to react ortho-and para-position hydrogens of the hydroxy groups on the ring group present in the compound represented by the formula (I') with an alkylating agent, and the coupling reaction is to react the product obtained from subjecting the compound represented by the formula (I') to react alkylation reaction in the second step with a coupling



(I')

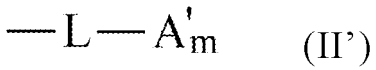
agent,

In the formula (I'), x groups G' are bonded to the ring group Ar, y groups R' are bonded to the ring group Ar;

x groups G' are, identical to or different from each other, each independently selected from -OH and H, wherein at least one group G' is-OH; x is selected from an integral number of 1-5);

y groups R' are, identical to or different from each other, each independently selected from

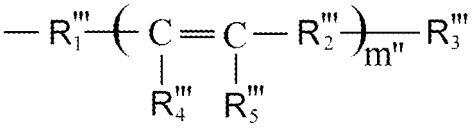
hydrogen, and a group represented by the formula (II'), wherein at least one group R' is selected from a group represented by the formula (II');



(II')

Groups L in y groups R' are each independently selected from single bond, (m+1)-valent C_{1-50} linear ; y is 1;

m groups A' in the formula (II') are each independently selected from a group represented by the formula (III'); the numbers m in the formula (II') is 1;



(III')

Wherein group R_1''' is selected from single bond and C_{1-20} linear or branched alkylene (preferably selected from single bond and C_{1-4} linear or branched alkylene); groups R_2''' in m'' repeating units are, identical to or different from each other, each independently selected from single bond and C_{1-4} linear or branched alkylene; group R_3''' is selected from hydrogen and C_{1-20} linear or branched alkyl (preferably selected from hydrogen and C_{1-4} linear or branched alkyl); groups R_4''' in m'' repeating units are, identical to or different from each other, each independently selected from hydrogen; groups R_5''' in m'' repeating units are, identical to or different from each other, each independently selected from hydrogen m'' is an integral number of 1-5, (preferably an integral number of 1-3);

The ring group 

is phenyl;

The above-mentioned "substituent group" is selected from C_{1-20} alkyl, C_{1-20} alkoxyl, C_{6-10} aryl, hydroxy, amino, mercapto and halogen atom.

6. The preparation process according to claim 5, which the sulfurizing agent is selected from an inorganic sulfurizing agent and/or an organic sulfurizing agent, more preferably, the inorganic sulfurizing agent can be selected from one or more of sulphur, Na_2S, K_2S, ZnS, H_2S and SCl; the organic sulfurizing agent can be selected from one or more of ditertbutyl polysulfide (DBPS), dimethyl disulphide (DMDS), dimethyl sulfide (DMS), ethyl mercaptan (EM), n-butyl mercaptan (NBM) and tert-nonyl polysulfide (TNPS).

7. The preparation process according to claim 5, which is characterized in that in the sulfurization reaction, based on the compound represented by the formula (I') or the product of the second step, the molar ratio of the compound represented by the formula (I') or the product of the second step to the sulfurizing agent is 1:1-6 (preferably 1:2-4); the sulfurization reaction temperature is 100°C-240°C (preferably 140°C-190°C).

8. The preparation process according to claim 5, which is characterized in that the esterifying agent is one or more of fatty acid, fatty acid anhydride and alkyl halide, wherein the alkyl is C_1-C_{30} linear or branched alkyl.

9. The preparation process according to claim 5, which is characterized in that in the esterification reaction, based on the compound represented by the formula (I') or the above-mentioned reaction product, the molar ratio of the compound represented by the formula (I') or the above-mentioned reaction product to the esterifying agent is 1:1-10 (preferably 1:2-8); the reaction temperature is 80°C-260°C (preferably 120°C-210°C).

10. The preparation process according to claim 5, which is characterized in that the alkylating agent is selected from one or more of halohydrocarbon, fatty alcohol and alkene, more preferably alkyl halide and/or alkene, for example can be selected from one or more of tert-butyl chloride, tert-butyl bromide, isobutylene and isopropylene.

11. The preparation process according to claim 5, which is characterized in that in the alkylation reaction, based on the compound represented by the formula (I') or the above-mentioned reaction product, the molar ratio of the compound represented by the formula (I') or the above-mentioned reaction product to the alkylating agent is 1:1-5 (preferably

1:1-2.5); the reaction temperature is 20°C-100°C (preferably 40°C-70°C).

12. The preparation process according to claim 5, which is characterized in that the coupling agent is preferably C_1-C_6 aldehyde, more preferably, the coupling agent is selected from formaldehyde, acetaldehyde, propionaldehyde, butyraldehyde, valeraldehyde or hexaldehyde.

13. The preparation process according to claim 5, which is characterized in that in the coupling reaction, based on the compound represented by the formula (I') or the reaction product, the molar ratio of the compound represented by the formula (I') or the reaction product to the coupling agent is 1-10:1 (preferably 2-5:1); the reaction temperature is 20°C-120°C (preferably 50°C-100°C).

14. The preparation process according to claim 5, which is characterized in that the phenol compound represented by the general formula (I') is derived from natural plant cashew.

15. A composition, which contains a phenol derivative according to any of claims 1-4.

16. A lubricating oil, which contains a base oil and a phenol derivative according to any of claims 1-4.

17. A lubricating grease, which contains a base oil and a phenol derivative according to any of claims 1-4.

18. Use of a phenol derivative according to any of claims 1-4 in the base oil of the lubricating oil.

19. Use of a phenol derivative according to any of claims 1-4 in the antioxidant.

20. Use of a phenol derivative according to any of claims 1-4 in the antiwear additive.

21. Use of a phenol derivative according to any of claims 1-4 in the lubricant.