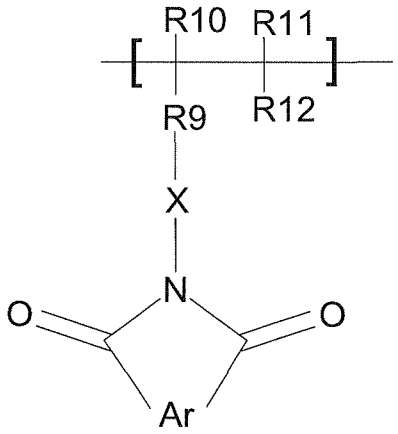
Summary

In an aspect, there is provided an electrode comprising an electrically conductive material in combination with an oligomeric or polymeric compound comprising at least two structural units of formula I

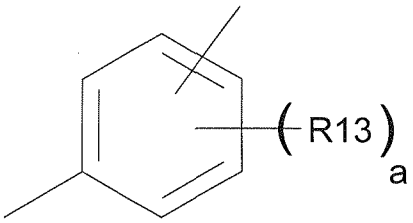


(I),

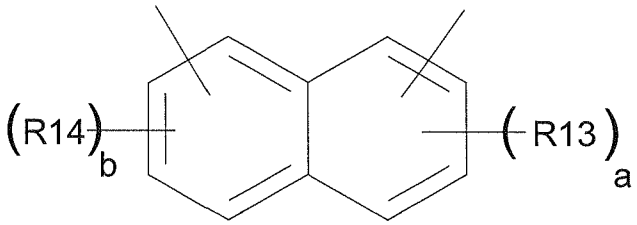
as redox-active material,

wherein

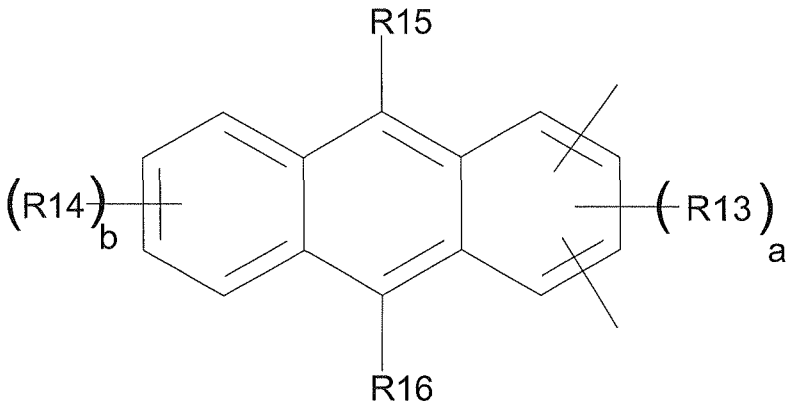
Ar is a group of formula IIIa, IIIb, IIIc or IIId



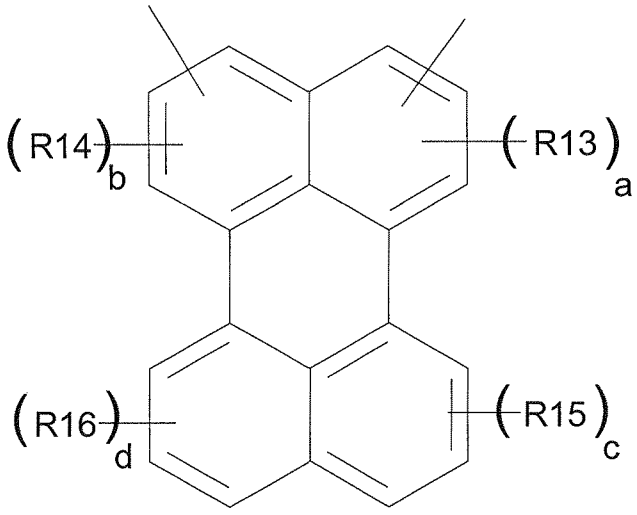
(IIIa),



(IIIb),



(IIIc),



(IIId),

wherein the covalent bond in group IIIa is in 2 or 3 position relative to the other covalent bond,

the covalent bonds in group IIIb are in 1, 2- or in 2, 3- or in 1, 8-position,

the covalent bonds in group IIIc are in 1, 2- or in 2, 3-position,

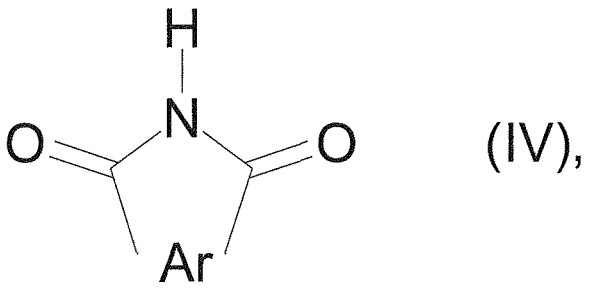
the covalent bonds in group IIId are in 1, 2- or in 3, 4-position,

R^{13}, R^{14}, R^{15} and R^{16} independently of one another are hydrogen, alkyl, alkoxy, cycloalkyl, aralkyl, aryl, heteroaryl, hydrocarboncarbonyl, carboxyl, carboxylic acid ester, carboxylic acid amide, nitro, hydroxyl, halogen, or wherein two adjacent alkyl substituents can form a ring system or wherein two adjacent carbonyl groups together with a nitrogen atom form a five-membered or six-membered imide ring,
a, b, c and d independently of one another are integers between 0 and 3,

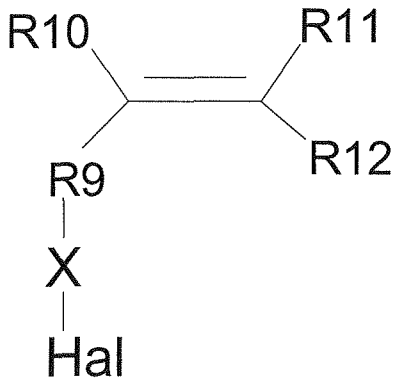
X is a divalent group selected from $-CR^1R^2-$, -CO-,
R^1 to R^2 independently of one another are hydrogen or alkyl,
R^9 is a a methylene group or a phenylene group or a covalent bond, and
R^{10}, R^{11} and R^{12} independently of one another are hydrogen or C_1-C_6 alkyl.

In another aspect, there is provided a process for preparing an oligomeric or polymeric compound comprising at least two structural units of formula I as defined herein comprising:

i) the reaction of a compound of formula IV with a compound of formula V

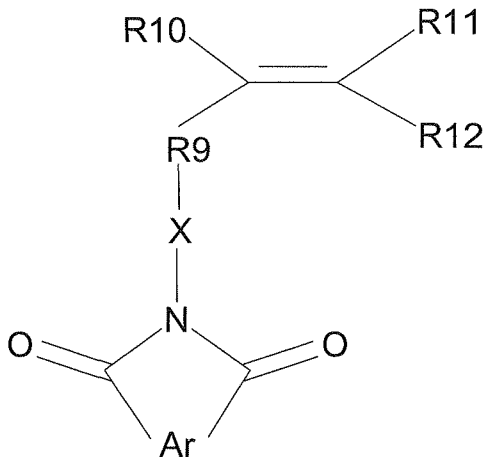


(IV),



(V),

in the presence of a base and a catalyst of formula $(PC^+)_e AN^{e-}$, to result in a monomer compound of formula VI



(VI),

wherein

Ar, R^9, R^{10}, R^{11}, R^{12} and X have the meaning defined herein,

Hal is a halogen atom,

PC^+ is a cation selected from the group of $[NR^{17}R^{18}R^{19}R^{20}]^+$, $[PR^{17}R^{18}R^{19}R^{20}]^+$ and $[SbR^{17}R^{18}R^{19}R^{20}]^+$, with R^{17}, R^{18}, R^{19} and R^{20} independently of one another being hydrogen, alkyl, cycloalkyl aryl or heteroaryl,

AN^{e-} being a e-valent anion, and

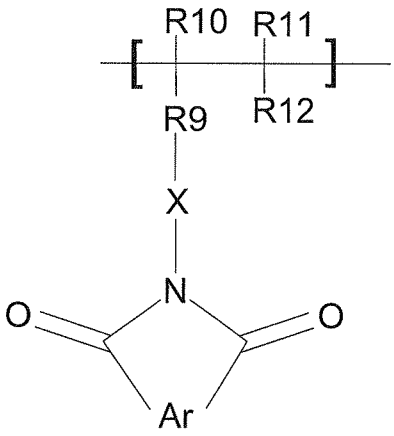
e being an integer of 1 or 2, and

ii) subjecting the monomer of formula VI and optionally other monomers copolymerizable therewith to conditions of radical, anionic, cationic or metallorganic polymerization to result in a polymer comprising recurring units of formula I described herein.

In a further aspect, there is provided a use of the oligomeric or polymeric compound comprising at least two structural units of formula I described herein as a redox-active material in storage means for electric energy.

Patent Claims

1. An electrode comprising an electrically conductive material in combination with an oligomeric or polymeric compound comprising at least two structural units of formula I

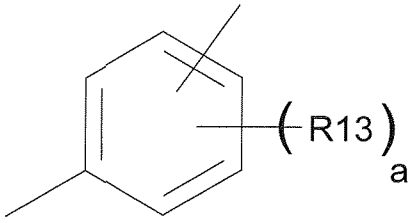


(I),

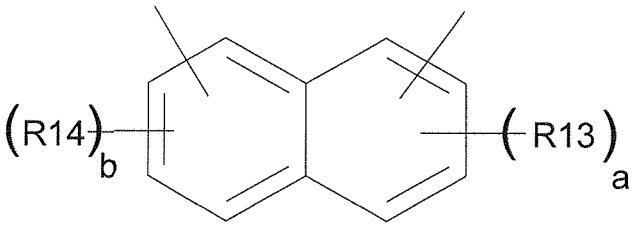
as redox-active material,

wherein

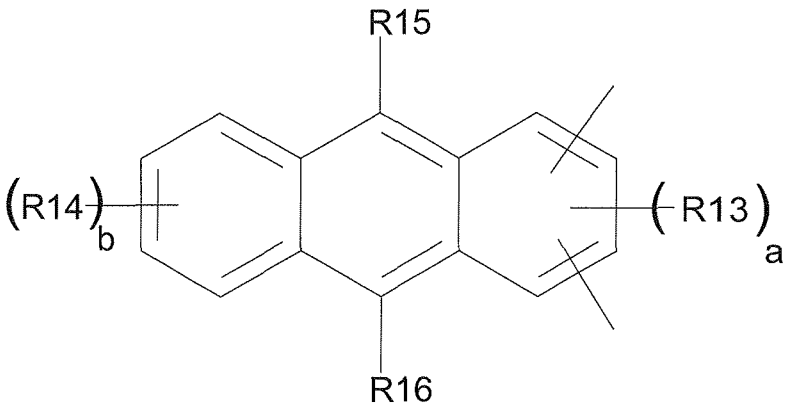
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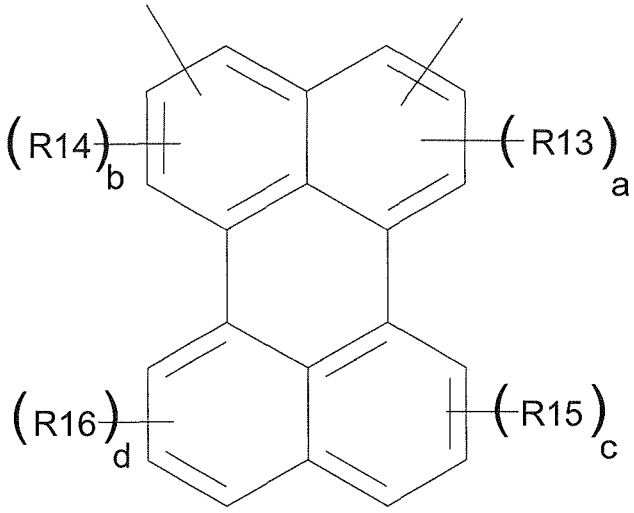
(IIIa),



(IIIb),



(IIIc),



(IIId),

wherein the covalent bond in group IIIa is in 2 or 3 position relative to the other covalent bond,

the covalent bonds in group IIIb are in 1, 2- or in 2, 3- or in 1, 8-position,

the covalent bonds in group IIIc are in 1, 2- or in 2, 3-position,

the covalent bonds in group IIId are in 1, 2- or in 3, 4-position,

R^{13}, R^{14}, R^{15} and R^{16} independently of one another are hydrogen, alkyl, alkoxy, cycloalkyl, aralkyl, aryl, heteroaryl, hydrocarboncarbonyl, carboxyl, carboxylic acid ester, carboxylic acid amide, nitro, hydroxyl, halogen, or wherein two adjacent alkyl

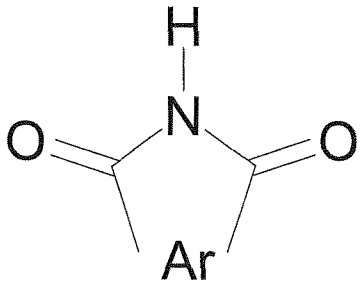
substituents can form a ring system or wherein two adjacent carbonyl groups together with a nitrogen atom form a five-membered or six-membered imide ring,
a, b, c and d independently of one another are integers between 0 and 3,

X is a divalent group selected from $-CR^1R^2-$, -CO-,
R^1 to R^2 independently of one another are hydrogen or alkyl,
R^9 is a a methylene group or a phenylene group or a covalent bond, and
R^{10}, R^{11} and R^{12} independently of one another are hydrogen or C_1-C_6 alkyl.

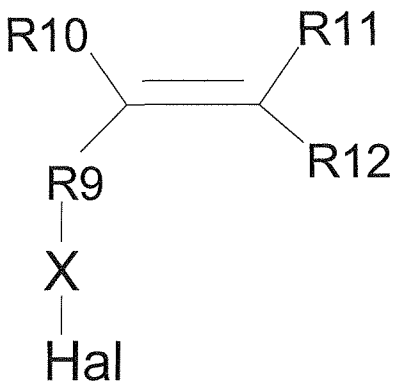
2. An electrode of claim 1, wherein R^1 to R^2 are hydrogen.

3. An electrode of claim 1, wherein R^9 is a covalent bond or phenylene, R^{10}, R^{11} and R^{12} are hydrogen or one of R^{10}, R^{11} and R^{12} is methyl and the other two are hydrogen and X is methylene or carbonyl.

4. A process for preparing an oligomeric or polymeric compound comprising at least two structural units of formula I as defined in claim 1 comprising
i) the reaction of a compound of formula IV with a compound of formula V

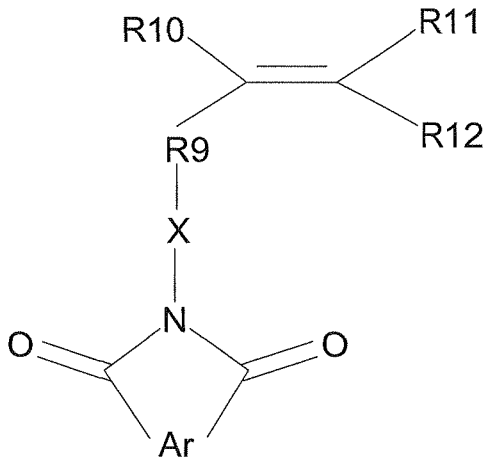


(IV),



(V),

in the presence of a base and a catalyst of formula $(PC^+)_e\,AN^{e-}$, to result in a monomer compound of formula VI



(VI),

wherein

Ar, R^9, R^{10}, R^{11}, R^{12} and X have the meaning defined in claim 1,

Hal is a halogen atom,

PC^+ is a cation selected from the group of $[NR^{17}R^{18}R^{19}R^{20}]^+$, $[PR^{17}R^{18}R^{19}R^{20}]^+$ and $[SbR^{17}R^{18}R^{19}R^{20}]^+$, with R^{17}, R^{18}, R^{19} and R^{20} independently of one another being hydrogen, alkyl, cycloalkyl aryl or heteroaryl,

AN^{e-} being a e-valent anion, and

e being an integer of 1 or 2, and

ii) subjecting the monomer of formula VI and optionally other monomers copolymerizable therewith to conditions of radical, anionic, cationic or

metallorganic polymerization to result in a polymer comprising recurring units of formula I of claim 1.

5. A process of claim 4, wherein Hal is chlorine, PC^+ is a cation $[NR^{17}R^{18}R^{19}R^{20}]^+$ with R^{17}, R^{18}, R^{19} and R^{20} independently of one another being hydrogen or alkyl, at least one of groups R^{17}, R^{18}, R^{19} and R^{20} being alkyl,
AN^{e-} being a halogen anion, preferably a chloride anion,
e being 1, and
the base being selected from the group of alkaline metal hydroxides, alkaline metal carbonates and alkaline metal hydrogencarbonates.

6. A process of claim 4, wherein the synthesis of the monomer compound of formula VI is performed in the absence of any solvent in a mixing device, in a ball mill or in an extruder.

7. A process of claim 4, wherein the polymerisation of the monomers of formula VI is performed as free radical polymerization in a solvent or in the absence of a solvent using a starter compound, wherein the starter compound is an organic peroxide, an organic hydroperoxide, a radical generating redox system or an azo compound.

8. A process of claim 4, wherein in the polymerization reaction for the manufacture of the oligomeric or polymeric compounds containing units of formula I of claim 1 different monomers of formula VI are used.

9. An electrode of claim 1, further comprising a binder agent.

10. An electrode according to claim 1 or 9, which comprises the oligomeric or polymeric compound of claim 1 in combination with a metal, a semiconducting inorganic material or an electrically conducting or semiconducting organic material.

11. Use of the oligomeric or polymeric compound comprising at least two structural units of formula I of claim 1 as a redox-active material in storage means for electric energy.

12. Use of claim 11, wherein the storage means for electric energy is a battery, a redox-flow cell, a fuel cell or a capacitor.